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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2

VOL. CX.—No. 2854.] *LONDON: FRIDAY, SEPTEMBER* 10, 1920. [*Registered at the General Post Office as a Newspaper.*] [PRICE...1s. 2d. BY FOREIGN POST 1s. 5d.

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See Advertisement page 93. 2469

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Tenders, addressed as noted on the form must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, September 29th, 1920.
(By Order) DUNCOMBE MANN,
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J 643

G. R.

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W.C. 2.
J 631

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND)

CONTRACTS, 1920.

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Tenders for the Supply of

the undermentioned STORES for Three Months commencing 1st October, 1920:—

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Baskets	10	Glass and China Sundries	37B
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Do. do. for Lamps	18A	Iron and Steel Wire	30A
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Do. do. for Gas ...	36B	Linen	8
Bunting	7B	Locks and Keys ...	19
Canvas and Sacks ...	6	Mats, Fibre	10
Carriage Laces ...	7A	Nails	31
Castings, Mall. Iron	11	Plumbago	41
Coach Screws and Washers	15	Rain Water Pipes and Gutters	35
Colours	2	Ropes, Twine, and Flax	4
Corks	39	Sewer Pipes, Plaster, etc.	32
Cotton Waste ...	5A	Shovels, Spades, etc.	31A
Crucibles	41	Soft Goods	6
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Forms of Tender can be obtained on *PAYMENT* of 6d. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G.S. & W.R., INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. Stamps cannot be accepted. All enquiries for information should be also directed to the Stores Superintendent.
Patterns may be inspected at the General Stores Department on and after the 10th inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).
Tenders must be enclosed in the special envelope supplied for the purpose with each Schedule, and must be posted so as to be with the undersigned before Ten a.m., on Wednesday, 22nd September, 1920.
The Directors will not consider any Tender unless it is furnished on the Company's Forms, and do not bind themselves to accept the lowest or any Tender.
By Order,
(Signed) ROBERT CRAWFORD, Secretary.
Kingsbridge Terminus, Dublin,
September, 1920. J 628

Steel Rails.—Tenders Wanted

for Manufacture and Delivery in England of Compound Tramway Rail.—Full particulars, etc., CAPTAIN THOMAS, 126, Upper Clapton Road, London. J 633

COUNTY BOROUGH OF ST. HELENS.

ELECTRICITY DEPARTMENT.

Tenders are Invited for the

SUPPLY and DELIVERY of 21 in. and 22 in. Bore CAST-IRON LOW-PRESSURE WATER PIPING.
Particulars of same may be had from drawings to be obtained from the undersigned.
Tenders, duly sealed and endorsed, addressed to the Chairman of the Electricity Committee at the Town Hall, not later than 30th September, 1920.
B. T. HAWKINS,
Borough Electrical Engineer,
St. Helens. J 661

COUNTY BOROUGH OF ST. HELENS.

ELECTRICITY DEPARTMENT.

Tenders are Invited for the

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B. T. HAWKINS,
Borough Electrical Engineer.
J 660

CITY OF LINCOLN.

The Lincoln Corporation invite

Tenders for the Supply,

DELIVERY and ERECTION of SPRAY COOLING PLANT, 500,000 gallons per hour together with PUMPS and PIPEWORK.
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Copies of the specifications can be seen at the office of the City Electrical Engineer, Mr. STANLEY CLEGG Brayford, Lincoln.
Tenders upon the prescribed forms, must be delivered at the Town Clerk's Office, Guildhall, Lincoln, not later than eleven o'clock on Friday, October 8th, 1920, and an official receipt must be obtained for any tender delivered by hand. Tenders sent by post must be registered.
The Council do not bind themselves to accept the lowest or any Tender. J 675

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

	Specification Fees.
1. Straight Axles (Forgings for Loco Engines).	2/6
2. Steelwork for Bridges (Wadi-Bundar Viaduct)	£1
3. Steel Castings for Bewas Bridge.	2/6
4. Copper Plates.	7/6

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned. The fee should accompany any application by post.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Straight Axles," "Steel Castings" or "Copper plates," as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 21st September. Tender for "Steelwork for Bridges" not later than Eleven o'clock a.m., on Tuesday the 12th October, 1920.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Secretary.
Company's Offices,
43, Copthall Avenue, E.C. 2.
London, 8th September, 1920. J 711

CITY OF SHEFFIELD ELECTRIC SUPPLY DEPARTMENT.

CONTRACT No. B. M. 56.

A.—TWO 10,000 KW. STEAM TURBINES.
B.—CONDENSING PLANTS, PIPEWORK, etc.
C.—ALTERNATORS AND EXCITERS.

The Electric Supply Committee of the City of Sheffield are prepared to receive

Tenders for the above.

Specifications, Forms of Tender and General Conditions of Contract, can be obtained from the undersigned, on and after Monday, 13th September, 1920, on payment of a sum of £2 2s., which will be returned on receipt of a bona-fide Tender, subject only to the complete Specifications and General Conditions accompanying the Tenders. Any person or firm sending in a Tender will be required to add a Schedule to such Tender stating the names of the various classes of labour which he, or they, intend to employ, together with the place where such labour will be employed, and the rates of wages, hours of labour and conditions of employment to be paid and observed in respect of each class of labour, all of which, as shown in such Schedule, shall comply with the City Council's Form of Clauses respecting wages, hours and conditions of labour, and prohibition against assigning or sub-letting. Tenders will be considered for all or any one of the complete sections. Tenders (enclosed in the official envelope provided), to be delivered at these offices not later than 10 a.m. on Tuesday, 12th October, 1920. The Committee do not bind themselves to accept the owest or any Tender.
S. B. FREDDEN, M.I.C.E., M.I.E.E., M.I.M.E.,
Commercial Street, Sheffield. J 686

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T. THORP, Secretary.
J 525

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DEPARTMENT OF ENGINEERING.

The Delegacy Require the

SERVICES of a LECTURER in Engineering with special reference to the Civil side, to take up his duties on October 1st. Salary £400 to £450 according to qualifications and experience. Applications with copies of not more than three testimonials should be sent not later than September 23rd to the SECRETARY, King's College, Strand, W.C. 2, from whom further particulars may be obtained. J 640

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.

Applications are Invited for

the following VACANCY:—
LECTURER IN ENGINEERING.
Salary scale.—£325—£10—£290—£15—£500.
In fixing initial salary full allowance will be made for years of service.
Particulars may be had from the PRINCIPAL to whom applications should be sent as early as possible. J 643

DARLINGTON COUNTY BOROUGH.

TECHNICAL COLLEGE.

Principal of Technical

COLLEGE WANTED. Candidates who must be Graduates, are asked to state salary required. Qualifications and experience in Engineering desirable but not essential. Full particulars may be obtained from H. WHALLEY, Education Office, Darlington.
6th September, 1920. J 668

SUNDERLAND EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.

Principal ... V. A. MUNDELLA, M.A., B.Sc.

The Committee invite

Applications for the Position

of ASSISTANT LECTURER in the Mechanical Engineering Department. Applicants must have had College or Technical Institution training, together with good Workshop experience. The duties include teaching in the less advanced day and evening classes and supervising testing in the Public Testing Laboratory.
"Scale of Salaries and Regulations Governing Appointments" may be had on application to the Principal.
Applications, with three references or testimonials, should reach the undersigned as soon as possible, and not later than 20th September.
HERBERT REED,
Chief Education Officer.
Education Offices,
16, John Street, Sunderland.
7th September, 1920. J 699

COUNTY BOROUGH OF BARROW IN FURNESS.

TECHNICAL AND JUNIOR TECHNICAL SCHOOLS.
Principal—D. HARDMAN, M.Sc.

Applications are Invited for

the POST of TEACHER OF ENGINEERING SUBJECTS. (Graduate or equivalent qualifications).
Salary according to experience and qualifications. Max. £450.
Further particulars may be obtained from the Director of Education, Town Hall, to whom applications should be forwarded on or before 14th September, 1920.
By Order,
L. HEWLETT,
Town Clerk and Clerk to the
Local Education Authority.
Town Hall,
30/8/1920. J 542

PORT OF LONDON AUTHORITY.

ENGINEERING DIVISION.

The PORT OF LONDON AUTHORITY are prepared to receive

Applications for the Appointment of ASSISTANT MARINE ENGINEERING SUPERINTENDENT.

Candidates, whose age must not exceed 36 years, must be Corporate Members of the Institution of Naval Architects and possess suitable qualifications. Also they must have been trained as Marine Engineers and have considerable experience in the design, construction and repair of dredging plant, tugs and other harbour service craft, both in respect to hulls and machinery. Sea-going experience, whilst not essential, is desirable.
Particulars of the conditions of service will be found on the Form of Application, which may be obtained at the office of the Chief Engineer, 109, Leadenhall Street, E.C., to whom all applications must be addressed and delivered not later than Noon on Monday, 4th October, 1920.
C. E. S. KIRKPATRICK, M.Inst.C.E.
Chief Engineer.
31st August, 1920.
109, Leadenhall Street, E.C. 3. J 556

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*Continued from page* 309.)

WE propose this week to continue our description of various of the machine tools on exhibition at Olympia. As before, we are dealing with the different classes of tools in sections, but we would again point out that these sections are selective only and do not pretend to deal fully with any class of the very large number of machines to be seen at Olympia. We may have occasion in a later article to return to any or all of the sections we now deal with. At no time, however, can we pretend to deal with the whole of the material on show, but in view of the importance both of the exhibition and of the industry for which it stands, we are devoting very considerable space to it and hope to illustrate or describe most of the important tools which are to be seen.

PLANING MACHINES AND SLOTTERS.

We may begin our detailed descriptions this week by referring to some of the planing and slotting machines which are on view. These are types of tool which, in general, lend themselves to no great novelty of design, but the display at Olympia is of value as illustrating the present standards in design and construction of these important classes of machine.

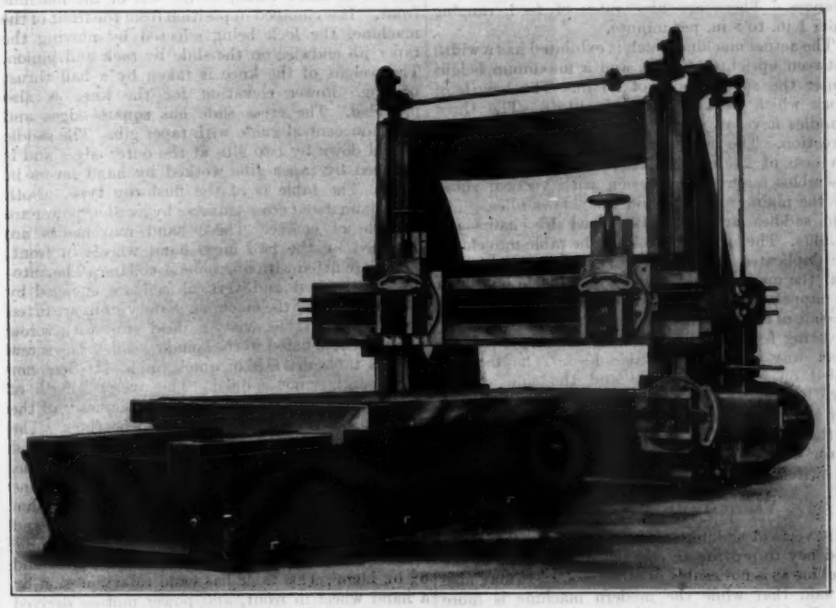


FIG. 54. 5-FT. BY 5-FT. BY 16-FT. "HILOPLANE;" MESSRS. JOHN STIRK AND SONS, LTD.

The first tool we illustrate this week is a 5 ft. by 5 ft. by 16 ft. planing machine constructed by Messrs. John Stirk and Sons, Limited, of Ovenden Road, Halifax. The machine which is shown in Fig. 54 on this page is of special interest as representing a model of which an order for 110 was placed during the war. The machines were for various Government factories engaged on the heavy gun programme. The order was subsequently extended and 117 of these planes had been built and delivered at the time of the Armistice. The tool is termed by its makers as "Hiloplane." It is entirely electrically controlled, and has, in addition to electrically-operated table mechanism, electric control for the tool boxes both in automatic feeds and quick power traverses. The machine is claimed to have the highest speed of any planer built, and at the same time to be capable of running at the lowest speeds necessary for special work.

The table is 4 ft. 9 in. wide and runs on flat sliding ways. Oil wells with rollers are provided for lubrication. The cheeks of the bed are continuous without openings, except at the gearing pits. The uprights are tongued, keyed and bolted to the bed and are tied together at the top by a cross-rail. The cross-slide carries two heads self-acting in all directions and a self-acting vertical slide is fitted to the near upright. The cross-slide is raised and lowered by power, the twin screws for the purpose being driven by enclosed worm-gears from a cross-shaft. Cross-planing may be carried out by either cross-slide head, the stroke being controlled by the same electrical mechanism which controls the main table motion. Table speeds from a minimum cutting speed of 15 ft. a minute to a maximum return speed of 240 ft. a minute are provided by the gearing in conjunction with the motor which has a speed variation of 8 to 1. The actual speed ranges are in low gear from a cutting speed of 15 ft. a minute up to 60 ft. a minute, with return speeds of from 60 ft. to 120 ft. a minute; in high-gear the range for cutting is from 30 ft. to 120 ft. a minute and for return from 120 ft. to 240 ft. a minute.

The electrical drive of the machine embodies a type of Ward-Leonard control and is a development of the Lancashire drive. The equipment consists of a motor generator which may be arranged for driving either by A.C. or D.C. current. This supplies a reversing motor which drives the table. Variations in speed are attained by control of the field of the generator, while reversal is obtained by reversing the connections. The special features of the Lancashire-Stirk arrangement are that the field windings of both the generator and the table motor are split into two sections. In the case of the generator these sections are connected to oppose each other, and alternative polarity, with consequent reversal of the driven motor, is attained by alternately exciting the two sections. In the case of the motor, the two sections are connected in the same sense. One section is permanently excited and the other is excited during the cutting stroke only. This provides a slow cutting speed and a quick return.

The electrical control of the whole machine has been worked out in a remarkable way and the facility and quickness with which the various motions can be put into operation is very striking. The automatic control arrangements for the whole machine are actuated from a disc and master-switch. This disc carries two dogs which may be fixed in any circumferential position round its edge. The dogs throw the master-switch over into one position or the other as they alternately come into working position owing to the movement of the disc. The latter is mechanically connected to the table mechanism and reverses its direction of rotation as the table reverses its movement. The master-switch controls the opening and closing of two contactors, and, owing to the simple electrical connections possible as a result of the split field arrangement, these two contactors are the only ones in the whole arrangement. The machine may be started by press button and in addition, a button is fixed above the master-switch which allows of inching.

All motions of the cross-slides are controlled electrically. The drive comes from a solenoid of variable stroke and the movement of the solenoid is connected with the master-switch. When setting up, the cross slides are controlled by a double press button, and the facility with which the slides can be raised, lowered, or run into any position is remarkable. Cross-planing is carried out by connecting the electrical arrangements to the vertical feed shaft and disconnecting them from the table. Change-over from table movement to cross-planing takes only about 15 seconds. An important feature in this electrical control of the feeds is that, when planing the feed takes place before the stroke begins, so that it is possible to work with very fine clearances in setting up. There are also no dogs or trips on the table for the feed, the whole arrangement being, on the face of one side frame, where it can easily be seen and got at. The only dogs on the table control an accelerator by which the motor field is weakened, and the generator strengthened on the return stroke, so that the table is speeded up. The main gear of the table has two positions giving high and low speeds. The intermediate speeds given by the electrical control we have already stated. All gearing is of steel cut from the solid, except the bull wheel, which consists of a steel rim on a cast-iron centre.

An interesting open-side planer is exhibited by Messrs. Ward, Haggas and Smith, of Keighley. This is illustrated in Figs. 55 and 56 on Plate XXXIV. The machine, the general arrangement of which will be clearly understood from the figures, has a 24 in. stroke, a horizontal travel of the tool of 22 in. and a vertical tool travel of 6 in. The table is 46 in. by 18 in., and the maximum distance from the table to the cross rail is 17 in. There are six changes of table speed, varying from 8 strokes to 70 strokes a minute. The table is operated by a crank motion and is held to the bed by gibs underneath, which restrain any tendency to lift. It runs in vees oiled by means of rollers running in oil pockets formed in the bed. As will be evident, the cross slide is adjustable up and down the column, and is balanced by a weight inside the column and connected up with a wire rope. The slide can be looked in any position. In addition to the vertical and horizontal feeds an angular power feed is also provided. All gearing, except the bull wheel, is of steel, machine cut, the ratio of the power gearing varying from a maximum of 60 to 1 to a minimum of 6 to 1. The driving pulley runs at 420 r.p.m. The machine on exhibition is driven by a 3 h.p. motor. This planer is a very workmanlike looking tool and should be very handy for many classes of work.

As examples of a somewhat allied type of tools, we may refer to some of the slotting machines which are on view. This is a class of machine which offers no great scope for originality, but a very interesting model is shown by Messrs. The Butler Machine Tool Co., Limited, of Victoria Ironworks, Halifax. Messrs. Butler show two shapers. The larger represents their standard model, which is built in six sizes from 6 in.–8 in. stroke to 24 in.–26 in. stroke. The machine shown is the 12 in.–14 in. model and has the body built in two parts, as is the case with all the larger machines. The machine has a speed gear-box contained in the trunk and the belt-shifting lever operates a brake for quickly arresting the ram. When the machine is driven by an independent motor, a friction clutch for starting and stopping the machine, without arresting the motor, is fitted. The lever which operates this clutch also operates a brake and the arrangement may be used for inching. The stroke mechanism is of the Whitworth quick return type combined with a spiral drive. The table slides are provided with quick power traverse motions and the feed motion is operated by a large circular cam from the main driving shaft.

The smaller and more novel slotter shown by Messrs. Butler is a 6 in.–8 in. machine, and is of the firm's patent tilting head type. This is intended

for die slotting and similar work requiring to be worked to a taper, and should be a very useful machine in many factories. As the taper effect is obtained by swinging over the whole upper part of the machine frame, and not merely by tilting the ram, the whole original stiffness of the machine is retained with the ram in any of its possible positions. The machine is illustrated in Figs. 57 to 59 on Plate XXXIV. The upper part of the frame carrying the ram revolves on a pivot and is operated by a worm and quadrant having a locking device, and the ram may be tilted 10 deg. on either side of the vertical. A scale allows the tilt to be easily arranged at the required angle. The upper part of the frame swings round the point at which the vertical feed rod drives a ratchet wheel, and as a result the tilting of the head does not interfere with the feed arrangements. The reciprocating motion for this rod is operated from a cam inside the upper part of the frame. The main pulley shaft carries a small flywheel at its other end and a brake attached to the belt fork lever comes in contact with this wheel and stops the machine instantly the lever is thrown over. A rotating tool box is fitted which has 180 deg. of movement and allows the tool to be worked at either side of the ram as well as at the front. All the usual power feeds are fitted to the table. The machine is a well finished and appears a well made and powerful tool for its size. Is should be of very considerable service for many classes of work.

Among other firms showing slotters are Messrs. The Atlas Engineering Co. of Bridge End, Leeds. They show a 9-in. stroke machine made by Messrs. G. Wilkinson and Sons, of Keighley. The machine follows standard lines and has a one-piece body and balanced ram, with Whitworth quick-return drive. A compound circular table is fitted which can, if required, be arranged to tilt. Circular, longitudinal and transverse feed motions are arranged for, actuated by a cam, connecting-rod and ratchet. In this group we may also mention the planing machine exhibited by Messrs. Cunliffe and Croom, Limited, of Broughton Iron Works, Manchester. It will plane articles 6 ft. long by 30 in. by 30 in. and incorporates various detail improvements, including a belt-striking gear of rotary type.

PLANO-MILLING MACHINES.

We illustrate this week three machines of the plano-milling machine type by Messrs. Kendall and Gent (1920), Limited, of Gorton, Manchester. The first is a 3½-in. horizontal machine of the slab type, illustrated in Fig. 60, Plate XXXV, and capable of milling a length of work of 8 ft., by 2 ft. 6 in. wide. The maximum height from centre of spindle to table is 24 in., and the largest-sized cutter used is 12 in. There are nine spindle speeds and nine feeds to the table, from 1 in. to 8 in. per minute. The table is driven by worm and rack. The cross-slide elevating motion is by hand. The machine is driven by a 17-h.p. motor by the Lancashire Dynamo Company, and the switch gear is by Messrs. Brook, Hirst and Co. The drive is of the all-geared type with double lever control to the gear-box. The drive is direct from the motor to the gear-box, while the drive to the feed-box is by shaft and mitre gears off the first motion shaft. The machine can be controlled from either side by two levers, one of which engages the feed motion and the other the hand. When both are disengaged the table is free.

The machine shown in Fig. 61, Plate XXXV, is a plano-profiling machine by the same makers. The motion in the machine exhibited is rather different from that illustrated, having been rearranged. The train of fine tooth gears at the side of the machine is replaced by a gear-box on the bed and a shaft and skew gears on the slide. The tool shown is also driven electrically, instead of by belt, as illustrated. The diameter of the spindle is 2 in., with vertical adjustment of 6 in. The traverse of the table is 6 ft. There are four spindle speeds, and three feeds. The distance from the spindle to the copying pin is 11½ in. The machine is driven by a 5-h.p. Lancashire Dynamo Company motor, and again the switch gear is by Messrs. Brook, Hirst and Co. From the motor, the drive to the main gear-box is by chain. From here the drive is taken to the feed-box and thence to the table drive inside the machine by a horizontal shaft. The spindle drive is by a shaft across the back of the machine to a pulley on a hinged bracket near the ground, and thence by belt to a pulley at the end of the back drum, an adjustable distance rod taking up the belt when the cross-slide is altered for height. From the back drum to the spindle the drive is by belt. The back drum has vertical adjustment as well as the cross-slide. For roughing the profiling lateral control of the spindle is usually by hand, and for finishing with the copying pin held against the former bar by a weight. The machine is, of course, suitable, in addition to such work as profiling, for keyway cutting, squaring shaft ends, &c.

A good example of the universal type of plano-miller is illustrated in Fig. 62, page 335. As stated above, this is also by Messrs. Kendall and Gent (1920), Limited. This is a large machine with one vertical and two horizontal 3-in. spindles. These machines are of the all-geared type. The combination of three spindles makes it possible to do a great deal of work at one setting. The spindle speeds range from 10 r.p.m. to 160 r.p.m. in 18 changes. There are nine rates of feed, ranging from 1 in. to 8 in. per minute.

The actual machine which is exhibited has a width between uprights of 4 ft., and a maximum height under the spindle nose of 36 in. The length of work which can be milled is 10 ft. The three spindles have an adjustment of 12 in. in an axial direction. The horizontal spindles have vertical traverse of 24 in. In general lines the machine resembles large planer design with vertical slides for the main cross-slide and the side saddles. The side saddles are counterbalanced by chains and weights. The levers controlling the table movement are duplicated on the two sides of the machine so that the operator need not leave the side on which he happens to be working. There is one lever on the side of the bed which moved one way engages the elevating feed for the side heads, and pushed the other way engages the table feed. The table is scaled off. The cross-slide and the side saddles have both hand and power vertical quick traverse, and the spindles have hand and power adjustment in the heads. This machine is also driven by a motor by the Lancashire Dynamo Company, with the switch gear by Messrs. Brook, Hirst and Co.

VERTICAL MILLING MACHINES.

IN vertical milling machines there is the same tendency to provide all controls at the front of the machine as is noticeable in other tools. It may also be said that while the modern machine is more complicated by reason of the multiplicity of power and hand motions demanded, at the same time it is becoming more foolproof by the introduction of automatic trips and interlocked gear levers, or by making one lever serve two conflicting functions, only one of which can therefore be chosen at a time. We have already noticed these developments in connection with drilling machines. The same trend can be followed in milling machines. There are a number of fine examples of vertical milling machines at the exhibition.

The latest model of vertical milling machine by Messrs. Alfred Herbert, Limited, Coventry, is illustrated in Fig. 63, Plate XXXVI. This is a very fine example of this firm's work, and is moreover interesting in that it follows in many respects the lines of the same firm's single pulley horizontal miller which was described in our columns in 1910 (see vol. XC, page 120). The general disposition of the controls in the two machines is very similar, and many of the parts are common to both types of machines. The range of speeds is identical and so on. The drive is by belt to a single pulley on the back of the column, mounted in ball bearings, the machine being started and stopped by operating a long hand lever pointing towards the front, near the head of the column. This lever operates a clutch. The spindle speed changes are 16 in number, all reversible. The gear-box is constructed as a separate unit built into the column. The changes are obtained by lever. The spindle speeds range from 16·4 r.p.m. to 427 r.p.m. The spindle is carried in an adjustable conical bearing at the bottom, and in an adjustable parallel bearing at the top. The bearings are of white metal, and the thrust is taken by white metal washers. The spindle is hollow and its nose is tapered externally and arranged for box clutch cutter drive. It is driven by a long spur gear near the bottom bearing and two keys at 180 deg. The spindle head is balanced, and is provided with quick rack-and-pinion adjustments, and fine adjustment by worm gear. These controls are seen on the near side of the head. The vertical adjustment of the spindle is 10 in.

The feed-change box is at the base of the machine; it is belt driven from the main drive, the pulley being on ball bearings. The feed variations, 18 in number, ranging from ⅝ in. to 22½ in. per minute, are all obtained by rotating an indicator dial. The feeds are reversible from the front of the knee. Two sets of gears cannot be engaged at the same time. The feeds are transmitted to the table, &c., by a vertical shaft and gears. The feed-box is automatically flooded with oil, and the feed gears on the knee run in an oil bath.

The knee is raised and lowered by a telescopic screw and hand wheel, to the left of the machine front. It is clamped in position from the front of the machine, the lock being effected by moving the taper jib endwise on the slide by rack and pinion. The weight of the knee is taken by a ball thrust bearing. Power elevation for the knee is also provided. The cross slide has square edges and a narrow central guide with taper gib. The saddle is held down by two gibs at the outer edges and is clamped by taper gibs worked by hand levers in front. The table is of the flush-top type. Both longitudinal and cross-traverse by hand or power are possible of course. These hand movements are obtained by the two large hand wheels in front, which are fitted with micrometer collars. The automatic cross-feed and vertical feed are engaged by levers in front of the machine. Safety stops are fitted to the knee, table, &c. A dead stop with screw adjustment is fitted to the spindle head. The screw for the table drive is of quick pitch. It does not rotate and is not splined. The overall length of the nut is more than ten times the diameter of the screw. The thrust is taken on ball bearings. The nut is driven by a wide spur gear. The table and cross-slide are oiled automatically from the inside.

The longitudinal feed of the table of this machine is 48 in., and the cross feed 18 in. The maximum distance from the spindle to column is 21 in., and from spindle nose to table tap is 26 in. The machine is fitted with a circular table, 26 in. in diameter and 6¾ in. high. This table has hand rotary motion by a hand wheel in front, and power motion derived from a horizontal spindle run off the feed spindle, at the back of the main table. This spindle which is necessarily above the main table is thus well out of the way. Everything would seem to have been incorporated in this machine which, by adding to the convenience and ease of operation may tend to increase output.

In Figs. 64 to 68, Plate XXXVI, we illustrate a vertical miller by Messrs. James Archdale and Co., Limited, Birmingham. This firm is showing two vertical machines, one with a table top 34 in. by 11 in., and the other, which we illustrate, with a table 44 in. by 14½ in. The smaller machine is rather more simple than the larger, having only nine spindle speeds, but it is capable of taking a cut 5 in. wide by 0·05 deep at the rate of 12·4 in. per minute, under test conditions, on mild steel. The larger machine, at the same rate of cut will take a cut 7 in. wide by 0·06 in. deep, and is generally capable of heavier work. The design of both machines is pleasing, the general lines of the smaller being similar to the larger, illustrated in Fig. 64. The drive of both is by constant speed belt pulley at the back of the machine, combined with a clutch, operated by a long lever pointing to the front of the machine on the right hand side of the head. The gear-box of this machine provides 18 speeds, from 28 r.p.m. to 630 r.p.m., by changes worked by three levers. The speed box is on the side of the upper portion of the column. The column with this gear-box removed is shown in Fig. 68, while the gear-box itself is illustrated in Fig. 65. The main pulley shaft is the lowest of all in the box. In

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

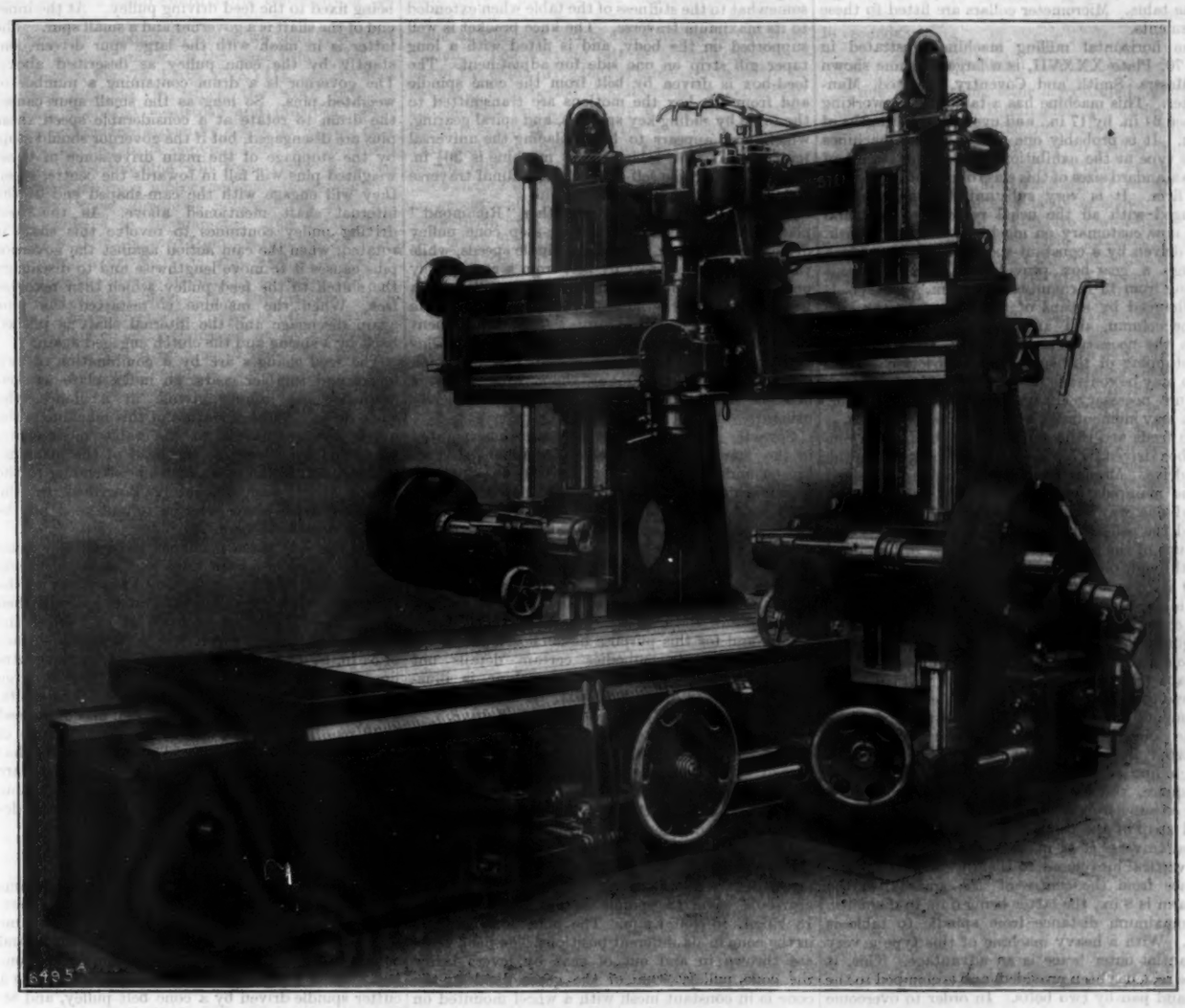


FIG. 62. UNIVERSAL PLANO-MILLING MACHINE; MESSRS. KENDALL AND GENT (1920), LTD.

Fig. 68 may be seen the gear on the spindle to the head. The spindle slide is balanced. It has quick and slow hand adjustment and is provided with clamps and micrometer stops. The spindle is hollow and arbors may be used with a draw bolt. The spindle end is of the box clutch type. The spindle is arranged for large facing cutters. It runs in one long taper bearing and one parallel bearing.

The feed drive is taken from the main pulley spindle in the speed change box, to the feed-change box fixed at the side of the knee, by a vertical spindle. Nine feeds are arranged, viz., 0·86 in. to 12·4 in. per minute, all reversible. The changes are controlled by levers on the box itself, but reversing can be accomplished either from the front of the machine, or at the back of the table. Fig. 67 shows the interior of the feed-change box and the vertical spindle from the main drive. The table drive is illustrated in Fig. 66. The table has hand or power longitudinal traverse of 30 in., and hand or power transverse traverse on the knee slide of 12 in., while the circular table on the main table has hand or power rotary movement. All these power movements are obtained from one spindle from the gear-box, through worms and bevels. The movement to the circular table is through a sliding spindle seen passing through a bevel-box. The feed screws are of quick pitch and are provided with ball thrust bearings. The hand longitudinal traverse of the table is obtained with the nearest hand wheel in Fig. 64, the cross-transverse movement by the hand wheel in front of the knee, and the elevation of the knee by the hand wheel which is only partially visible on the left hand side of the knee. Vertical adjustment of the table can be made to the extent of 18 in., and of the spindle slide, 5½ in. The longitudinal and transverse movement hand wheels are fitted with indexed collars, and the circular table has an indexed disc. The maximum distance from the spindle to the table is 20 in., and from the centre of the spindle to the column is 16 in. When arranged for electric drive a 5-h.p. motor is fitted.

Two vertical milling machines are also being shown by Messrs. Kendall and Gent (1920), Limited, Manchester. These are of the all-geared type with 18 spindle speeds and nine feed speeds, all changes being by levers. The spindle is carried in a sliding bracket with vertical movement, the driving gears being encased in the top of the column, the spindle itself being driven by wheel with sliding key. Power movements and automatic trips are provided for the table and saddle. The larger machine is fitted with an arbor support to hold a copying pin for profiling, in conjunction with a template under the work.

HORIZONTAL MILLING MACHINE.

The examples of horizontal milling machines of the so-called Universal type are not quite as numerous as might be expected at an exhibition of this character. This type of machine has been reduced to a comparatively few distinctive forms though many machines have, of course, distinctive details. Perhaps it is a sign of the times that the all-round machine is not quite so prominent as was one time the case, yet there is of course a large market for such tools in shops of the first class, whose work is not easily reducible to mass production on special tools. The first horizontal miller we illustrate is one by Messrs. Cunliffe and Croom, Limited, Manchester. It is shown in Fig. 69, Plate XXXVII. This is a single pulley machine with clutch engaged by the long lever on the right side of the column below the three speed-change levers which give 12 spindle speeds. The drive to the feed-change box is by chain from the constant-speed shaft. Nine changes of feed are arranged to all table movements, the drive from the box to the knee being by universal shaft. A small lever on the knee at the end of this shaft is for reversing the feed. Another near the outer end is the cross-feed trip, while one near the centre of the saddle is the table trip. Automatic trips are also fitted. The table swivels 45 deg. either way, on the saddle. The working surface of the table is 53 in. by 12 in. The automatic traverse is 36 in., with 10 in. cross-traverse and 19 in. vertical movement to the knee. The first and second range from 0·5 in. to 6 in. per minute, the last from 0·125 in.

to 1·5 in. per minute. Hand wheels at the front are for cross-traverse and elevating motions only. The table traverse is hand-operated from the end of the table. Micrometer collars are fitted to these movements.

The horizontal milling machine illustrated in Fig. 70, Plate XXXVII, is a large machine shown by Messrs. Smith and Coventry, Limited, Manchester. This machine has a table with a working surface 64 in. by 17 in., and overall table lengths of 72 in. It is probably one of the largest machines of its type at the exhibition, and is the largest of three standard sizes of this class of machine made by this firm. It is very substantially built and is arranged with all the usual power traverses and trips now customary on machines for heavy work. It is driven by a constant-speed belt pulley, which through a gear-box provides 16 spindle speeds ranging from 13·3 r.p.m. to 350 r.p.m. The speeds are changed by means of three discs on the side of the column, and an indicator plate alongside shows the necessary combinations. The starting and stopping of the spindle is by friction clutch, which may be controlled from three positions so that it is not necessary always to return to one lever, which may momentarily be inconvenient to reach.

The feeds are 16 in number, all obtained in one gear-box driven by a constant-speed pulley from the main drive. Moreover, all the 16 feeds are obtained by the manipulation of one handle, which, when turned one way gives increasing feeds, and when turned the other way gives decreasing feeds. One half turn of the handle suffices to raise or lower the feed through one step, the range being from ¼ in. to 20 in. per minute. An indicator shows what feed is in use. The feeds are self-acting in all three directions and reverse, and the controls are all brought to the normal working position. The hand controls for the longitudinal and cross traverse of the table are by hand wheel; the vertical hand traverse to the knee is by lever handle. The power movements are transmitted from the gear-box to the knee through a vertical shaft which is supported in bearings at the top and bottom. The guiding edges on the knee for the cross-slide are square, the actual guiding of the cross-slide being effected by a comparatively long and narrow raised strip in the centre of the slide. The longitudinal traverse is 42 in. and cross-traverse 15 in., with vertical movement to the knee of 20 in. The distance from the centre of the spindle to the over-arm is 8 in., the latter being 5 in. in diameter. The maximum distance from spindle to table is 20 in. With a heavy machine of this type a very substantial outer brace is an advantage. This, it will be seen has been provided, and is clamped to the knee and pan by two bolts. In order to overcome the inconvenience in working with such a brace, the arbor end is carried in a large disc bearing which is detachable, leaving a hole in the brace of big enough diameter to pass cutters and arbors through. The lubrication system consists of a pump forcing oil from a sump in the column base up to a glass indicator on the top of the machine, whence it is distributed to a trough, and thence to all the shaft bearings, revolving gears and so on.

The horizontal milling machine shown by Messrs. Midgley and Sutcliffe, Richmond Tool Works, Bradford, is one of the few with drop-clutch handles in place of the more general hand-wheel controls. There is, of course, something to be said for this type of handle, which, immediately pressure is relieved, disengages and drops out of the way. On the other hand, the hand wheel is always in the same place, and a man can feel for it and make an adjustment by the rim without looking up from his work, with an ease which is not possible with a lever. For this reason we are inclined to the hand-wheel control, although the rims are in some designs made to project to inconvenient heights.

Messrs. Midgley and Sutcliffe's No. 2A "Richmond" milling machine is illustrated in Fig. 71, Plate XXXVII. This is a comparatively simple machine with six spindle speeds and four rates of feed for each spindle speed. The main drive is by a three-step cone pulley with back gear. One of the special features of this model of milling machines is the long table slide provided. Instead of the usual small saddle and short table slide, the saddle or cross-slide is extended to either side, giving a long upper slide for the table, equal in length to the table itself. This adds, of course, somewhat to the stiffness of the table when extended to its maximum traverse. The knee bracket is well supported on the body, and is fitted with a long taper gib strip on one side for adjustment. The feed-box is driven by belt from the cone spindle and from the box the motions are transmitted to the table by sliding key spindles, and spiral gearing, which now appears to be displacing the universal joint drive. The table in this machine is 36½ in. by 10 in., while the self-acting longitudinal traverse is 24 in., and the cross-traverse 7 in.

The same firm is showing another "Richmond" plain milling machine with three-step cone pulley drive and back gear, giving six spindle speeds, while the feeds are run direct by belt from a cone pulley on the main spindle down to a cone pulley on a bracket, whence the motion is carried to the table by a shaft with universal joints. This arrangement gives three feeds for each spindle speed. This machine is a simple straightforward type, for which use can be found in many shops where a large machine of wider capacity would not be economically utilised.

Several interesting features are incorporated in the machines of this class by Messrs. J. Parkinson and Son, Shipley. This firm is exhibiting four machines, two with cone pulley drive and two with single pulley drive. Each type is shown in two sizes. In our issue of August 27, on pages 268 to 270, both these tyyes were very completely described and illustrated, and we must therefore refer our readers to that account for illustrations of details of the machines. We now propose to deal with some of the main features of the cone pulley model, and for this purpose have chosen the larger machine, as this embodies certain details not included in the smaller. The machine is illustrated in Fig. 72, Plate XXXVII, the chief feature of this design being the independent feed drive.

A very compact two-speed counter-shaft is designed for this class of machine, which is self-contained and is provided on one side with a pulley cone corresponding with the machine cone pulley, and on the other side with a pulley giving a constant and independent drive to a belt pulley on the feed-box at the back of the machine. The spindle drive is by a three-step cone pulley with two rates of back gears, which, with the countershaft gear-box, give 18 spindle speeds, ranging from 13 r.p.m. to 400 r.p.m. The cone lock engages in the cone in six different positions. The back gears are thrown in and out of gear by levers below the cone pulley. One of the gears fixed to the cone is in constant mesh with a wheel mounted on a sleeve on the back shaft. When this ratio is wanted the wheel and sleeve are engaged by a clutch. Otherwise they run free, though at all times, when the machine is in motion, controlling the independent feed drive as will be explained.

The principal objection to independent feed driving is that in the event of a failure of the main belt the feed will continue to act, to the eminent risk of the cutter, the work and the machine. On the other hand, with a cone pulley drive the advantages of independent feed drive are so considerable that they can hardly be ignored. With cone pulley drive, and feed drive from the main drive, the possible feed combinations are restricted to an extent which considerably limits the capacity of the machine; or we may put it the other way: with independent drive the possible combinations are far more numerous. In the Parkinson arrangement any one of 18 spindle drives can be combined with any one of 16 feeds, ranging from ¼ in. to 14·8 in. per minute. This allows of a wider range of work than is usual with machines in which the feed drive is directly related to a belt spindle drive. In order to obtain this advantage and yet obviate risks such as are referred to above, Messrs. Parkinson have a safety device on their millers which disengages the feed as soon as the main drive is stopped either intentionally or accidentally. This is practically the same for both machines as the arrangement described on page 269 *ante*.

The driving shaft of the feed gear-box is hollow and contains another shaft capable of a certain movement endwise in it. The inner end of this shaft is cut to a cam shape. At the outer end is fastened one member of a clutch, the other member being fixed to the feed driving pulley. At the inner end of the shaft is a governor and a small spur. The latter is in mesh with the large spur driven constantly by the cone pulley as described above. The governor is a drum containing a number of weighted pins. So long as the small spur causes the drum to rotate at a considerable speed these pins are disengaged, but if the governor should stop, by the stoppage of the main drive some of these weighted pins will fall in towards the centre, when they will engage with the cam-shaped end of the internal shaft mentioned above. As the feed driving pulley continues to revolve this shaft is rotated, when the cam action against the governor pins causes it to move lengthwise and to disengage the clutch to the feed pulley, which then revolves free. When the machine is restarted the pins again disengage and the internal shaft is pushed back by a spring and the clutch engaged again.

The feed changes are by a combination of two levers and tumbler gears, an index plate marked in inches per minute giving, at a glance, the work done. Another feature of this machine is the quick power traverse to the table movements, controlled by a lever at the head of the machine, within reach of the operator while attending to the work. This was adequately described in the previous article above referred to and need not be further dealt with here.

For the rest these machines have all the usual motions, with automatic trips and so on, including feed reverse, which may be used to stop any of the traverses, controlled from a double lever reached easily from a position in front of or behind the table. The table, which has a working surface of 57 in. by 12 in., swivels to each side of the centre line to 50 deg. The swivelling base is of large diameter and the table is clamped by three bolts. The power longitudinal feed is 36 in. and cross-feed is 12 in. The greatest distance between centre of spindle to table top is 20 in. The largest cutter that can be used is 14¾ in. These dimensions are similar for the large constant-speed drive machine shown by Messrs. Parkinson and previously described in our columns, as mentioned above.

AUTOMATIC CAM AND CAMSHAFT MILLERS.

Two machines for the quick production of cams and camshafts by milling are shown by Messrs. Webster and Bennett, Limited, Coventry. One of these, for cam cutting, is a duplex machine, and consists of two independent tools mounted on one bed. Each tool consists of a headstock carrying a cutter spindle driven by a cone belt pulley, and an automatic slide carrying a spindle, driven by belt and gearing, on which are mounted both the work and the master cam. The movement of the cross-traverse is controlled by a heavy weight pulling the master cam up against the copying roller on the usual principle. Various special features contribute to the variety of work this machine can perform. The whole slide racks along the bed to bring the work up to the cutter, and a lever with an eccentric quickly withdraws the work from the cutter by a short cross-traverse movement sufficient for a new blank to be set up. The feed revolves the work against the cutter, and an adjustable trip is arranged to throw it out at any point, this being effected by a sliding clutch on the spindle of the worm driving the work spindle. The worm drive to the work spindle is fitted with a slipping device which is an essential feature of the machine, in order to make it possible to negotiate outlines which would not otherwise be possible. It comes into action, for instance, when a regular or irregular circumferential motion has to be temporarily replaced by a radial movement of the cutter. When this is necessary the feed drive is allowed to slip to some extent while a roller on the driving clutch comes in contact with an inclined plane set on the saddle. This causes the work slide to traverse until the circumferential feed is resumed. Master cams can be cut on the machine, and an astonishing variety of work can be carried out in addition to ordinary cam cutting, as, for instance, machining both the inside and outside of bicycle fork crowns, levers of all sorts of

irregular shapes, magneto parts, rifle parts and so on. The samples of work shown at Messrs. Webster and Bennett's stand afford ample testimony of the versatility and high output of this tool.

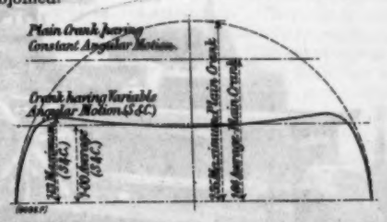
The other machine to which we shall now refer is the camshaft miller by the same firm. This we illustrate in Fig. 73, Plate XXXVIII. It is also a copying machine, in which the work revolves between a special headstock and tailstock, while the milling cutter, driven by a belt, is carried on a slide controlled by a copying roller and a strong spring. This machine will form eight cams out of solid discs on a motor camshaft in 24 minutes. The headstock spindle is hollow; the hole will pass blanks 4 in. in diameter. The rotary feed for the work is obtained from the first-motion shaft of the cutter drive. It is controlled by a friction clutch on the hollow spindle, by means of the star wheel at the left hand end of the machine. The tailstock has a collet which grips the other end of the shaft. This collet is tightened by a cross-handle, and may be locked by a small lever over the tailstock. The main spindle carries, just to the right of the headstock two master cams set for the relative positions of the exhaust and inlet cams to be cut. The tool slide and copying fixture needs little description except that the latter can be made to traverse a short distance longitudinally relatively to the cutter support, in order to bring it first into contact with one cam and then with the other. After one cam has been milled the next is cut by transferring the operation to the other master cam by traversing the copying roller, the tailstock and shaft being moved the required distance to the right. Having cut the second cam the feed is stopped and the chuck and shaft revolved till the dividing head of the tailstock has passed from the first position to one at 90 deg. to it, the work and tailstock again being moved towards the right. The operation is then repeated first for one cam and then for the other. With a suitable cutter re-entrant angles are easily possible. The copying roller adjustment is graduated in thousandths of an inch to facilitate accurate gauging. The setting operations, although sounding rather complicated when detailed, are very straightforward and quickly mastered. The machine is really very simple and is a comparatively cheap substitute for a grinding machine with cam attachment.

KEYWAY CUTTING AND MORTISING MACHINES.

Leaving over for the moment the description of the machine illustrated in Fig. 74, we next describe two machines which use end mills for the purpose of cutting keyways and slots. One is the usual type of keyway cutter and slot drilling machine which may be used for both heavy and light work. This machine, shown in Fig. 75, Plate XXXVIII, is by Messrs. George Richards and Co., Limited, Broadheath. Although the table itself will not accommodate very large work this tool, having a traversing cutter spindle, will cut keyways or cotter holes 1¼ in. wide by 30 in. long. This is longer than is possible with a reciprocating crank machine. It is automatic in action. The drive is by belt from a countershaft, the spindle being driven by belt, with a range of eight speeds. The table is 30 in. long and 12 in. wide with a vertical movement of 14 in. and a cross-traverse of 6 in., so that the tool may be used for a large range of jobs. The spindle has vertical self-acting traverse of 4½ in. and an automatic stop regulates the depth of the cut.

A machine of quite another type, capable of dealing with heavy work, is shown by Messrs. Smith and Coventry, Limited, Manchester. This is illustrated in Fig. 76, Plate XXXVIII, and is intended for cutting keyways in railway axles, cotter holes in pistons, pump rods, &c. It will cut key-seats 1¼ in. wide, and 12 in. long, or cotter holes, through diameters of 7 in. This tool is provided with a worktable at one end of which is a vice with vee-gripping jaws, while towards the other is an adjustable tailstock with jaw grips. The work is held between the tailstock and vice. At one end of the machine are two heads, placed across the bed and each carrying a revolving milling cutter, these being exactly opposite each other. These cutters can be fed in towards each other, and are controlled in a variety of ways, while the table is traversed longitudinally. The main drive is by single-belt constant-speed pulley.

The table traverse is arranged by the adjustable crank at the near end of the machine in our illustration. The varying rate of traverse due to a use of the crank drive for the table is reduced to one having a long period of uniformity by counteracting the final crank drive by a special gear interposed between the main drive and the disc crank. This gear is an adaptation of the Whitworth quick-return motion used on slotters. It consists of three sliding blocks and three discs, two of which are eccentrically mounted, transmitting the uniform worm-drive from the constant-speed main drive to the crank-disc through gears. The final speed curve of the table is as shown in the diagram subjoined.



The number of single strokes can be varied from 2·6 to 36 per minute by means of change wheels. The table is adjustable along the crank-rod by rack and pinion, so that it can be set to the required position for the work after the latter has been approximately set in the vices. The crank-pin has a setting scale on the crosshead, so that length of travel may be quickly set.

The spindle slides can be racked towards or away from the centre line of the machine. The slides may be moved independently, or together by the simple expedient of tightening a milled nut. The spindles have spring collets to hold the cutters, and they are hollow and of sufficient bore to allow of the cutters being withdrawn through them backwards. The spindle speed ranges from 0·005 in. to 0·05 in. per traverse, for each spindle, the cutters having three speeds, viz., 349 r.p.m., 400 r.p.m. and 693 r.p.m. The feed is controlled by one lever, which has three positions for different operations. In one position of the lever the feed acts only on the front spindle and cutter, as for ordinary key-seating. In the same position the feed acts on both cutters if the milled nut above referred to is clamped, so that key seats can be cut on opposite sides of the work simultaneously. In the second position this lever controls the cutters for mortising or cotter-hole cutting. In this the two cutters are fed towards each other until very little metal remains between them when the back head is automatically tripped and withdrawn. The front cutter meanwhile continues to be fed forward, cutting away the remaining web and cleaning up the hole, when it is automatically withdrawn. In the third position of the lever the feeds are disengaged. The feed is automatic and applied at the end of each traverse. It is operated by a fine tooth ratchet and worm to a rack on the cutter slide, and is varied by setting a stop collar on a feed rod with graduated scale. The large crank handle in the centre of the bed is used for the changes of spindle speed, one revolution first disconnecting the main clutch, then sliding the next gears into place, and finally re-engaging the clutch.

The machine has a work-table 48 in. long by 12 in. wide, and the maximum distance apart of the spindle noses is 15 in. A simple cotter taper attachment can be fitted, suitable for tapers up to 1½ in. per foot. This consists of a swivelling table which is rocked by a crank disc driven at the same rate as the crank which operates the table traverse. By timing and adjusting the crank stroke the taper can be varied and different degrees obtained at the two ends of the slot, if desired.

It should be mentioned that an automatic depth trip is fitted to the feed. This is adjusted by bringing the cutter up to the work and then moving the trip stop back to a gauge for the proper depth, when the feed will be tripped.

We are informed that this machine will cut ½-in slots, 8 in. long, to a depth of ¼ in. in 10½ minutes. A 1¼-in. slot, 4 in. long by ⅝ in. deep, can be cut in 13 minutes. A ¼-in. cotter hole 2 in. long can be cut in a 2-in. bar in 5 minutes 10 seconds.

AXLE-TURNING LATHES, &c.

A new axle-turning lathe is exhibited by Messrs. Tangyes, Limited, of Birmingham, for whom Messrs. Alfred Herbert, Limited, Coventry, are agents. The same firm is also showing an axle ending and centring machine. The latter, which we may deal with first, is illustrated in Figs. 77 to 80, Plate XXXIX, while the axle lathe is shown in Figs. 81 to 83, page 338. Both are motor-driven and embody features of more than ordinary interest. The axle-centring machine will deal with axles from 4 ft. 9 in. to 9 ft. 6 in. long and up to 9 in. in diameter. The machine has two driving headstocks which receive their motion from a shaft running down the centre of the bed. There are also two saddles, and one vice, with adjustable vee jaws, placed in the centre of the bed. The headstocks have holes 10½ in. in diameter. The speeds are four in number, obtained with the gear-box between the motor and the machine. Each headstock has a scroll chuck actuated by worm gear, for gripping the work.

Each saddle carries a front and a back tool slide, and a centring spindle. The tool slides may be seen in Figs. 79 and 80, Plate XXXIX.

The front slide has automatic surfacing motion which is tripped by an adjustable stop rod depressing a lever on the apron, thus disengaging the worm feed shaft at the front of the machine. This arrangement may be seen in Fig. 80. Keyed to the stop rod is a handle, seen hanging straight down in Fig. 80. This enables the operator to trip the feed at any moment. The back tool slide also has automatic feed for turning the collars. This rear slide is automatically tripped by the same stop-rod and handle as the front one, one stop being used to disengage both feeds. The front and back tool slides are operated by hand by two of the squared shafts seen in the front of the saddle. The third shaft of this group is for lateral adjustment of the back tool slide, the front slide being adjusted in this sense by a small handle of the ordinary type.

The centring spindle is carried on a slide which is racked in and out from the work by a large capstan hand wheel. The spindle carries a "Coventry" quick-change chuck; it is driven by an independent 1½-h.p. motor, shown in Fig. 78, through gears. The spindles are fitted with ball thrust bearings. The feed motions to the saddles are independent for the two ends of the machine, being obtained off the main driving shaft by change wheels at each end of the bed. Each saddle is coupled to its headstock by adjustable rods and nuts. The lever to be seen in the centre of the bed is for throwing in quick power-traverse for the headstocks either outward or inward, for the purpose of inserting or withdrawing axles. An automatic stop is provided for this movement so that the headstocks will always stop at the same point for one length of axle. This traverse is at a speed of 5 ft. per minute. The shaft is driven off the first-motion shaft in the gear-box.

The gear-box is arranged with a friction clutch and four speeds obtained by the levers seen at the left-hand end of the machine in Fig. 77. The length of the bed is 20 ft. The work speeds range from 28 r.p.m. to 63 r.p.m. The centring drill speed is 360 r.p.m. The main motor is 15 h.p., running at 900 r.p.m. The small motors, as already mentioned, are 1½ h.p.; they run at 1,950 r.p.m. Fig. 78 gives a view of the back of the machine and shows the ball bearing collar on the jib serving it.

In works where this machine has been installed axles have been faced, centered, and the collars turned in floor-to-floor time of less than 20 minutes, or with one man and a helper in less than 10 minutes.

The axle turning lathe is shown in Figs. 81, 82 and 83, page 338, of which Fig. 81 gives a general view. The single headstock has an 11-in. hole for taking the work, and is fixed to the bed. It is driven in the usual way by a longitudinal shaft and spur and pinion, with intermediate gearing. This main shaft is driven by a four-speed change gear-box

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

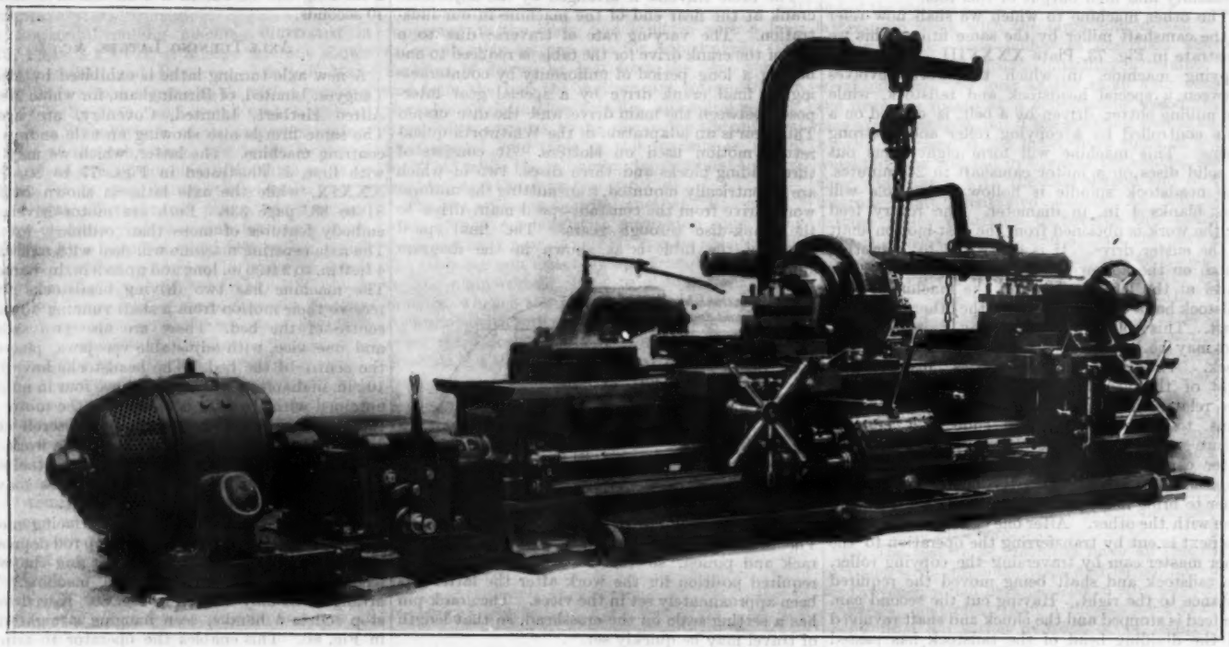


FIG. 81. AXLE TURNING LATHE; MESSRS. TANGYES, LTD.

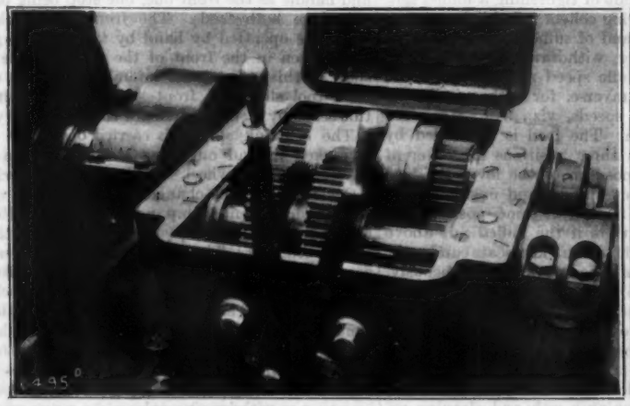


FIG. 82. GEAR-BOX OF AXLE TURNING LATHE.

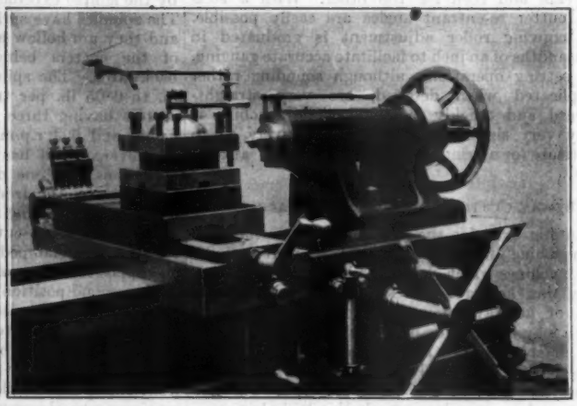


FIG. 83. SADDLE OF AXLE TURNING LATHE.

at the left-hand end of the machine (Fig. 81). This gear-box, which is the same as is used in the centring machine already described is shown in Fig. 82. Additional combinations are obtainable with the upright lever below the headstock, giving eight changes in all, with correct speeds for changing from rough to finish turning obtainable by the operator while attending to the work.

The feeds to the two saddles are independent, with automatic motion in only one direction, that is in either case towards the headstock. The feed shafts are in front of the machine. Below them are stop rods fitted with dogs which can be set to control quite short lengths of work. Three changes of feed are obtainable in each case with a single lever for each saddle. The traverse to the tool slide is by hand only. The saddles can be hand-racked along the bed in addition to power movement, which is engaged by lifting a small vertical rod shown on the apron in Fig. 83. This movement may be disengaged by moving either to the right or left a lever shown hanging down from the saddle in Fig. 83. At the back of the saddle may be seen, in Fig. 83, four finger dead stops, one for each tool of the square turret. These may be adjusted for the various diameters to be worked to.

The left-hand tailstock is arranged to swivel; the right-hand one is adjustable by hand wheel and screw. The axle is carried by the two tailstocks and rotated by an equalising driver on the front of the spindle of the headstock. The work speeds are from 12 r.p.m. to 80 r.p.m., while the feeds are 6, 12 and 22 cuts per inch. Attention may be drawn to the jib crane provided. This is fitted with a ball bearing support. The lifting fixture shown enables the work to be slung out of centre so that it may be passed into the headstock without shifting the sling. The machine is provided underneath with a chip tray on wheels, while reference to Fig. 83 will show the tool slide to be lipped so as to form a tray from which the suds are taken by a channel to the main tray. This assists in keeping the machine clean.

Another axle-turning lathe exhibited is by Messrs. John Lang and Sons, Limited, Johnstone. This machine is of the same class general type, with hollow spindle headstock and two loose tailstocks. The main drive is by belt to three-speed gear-box on the end of the bed, and thence by horizontal shaft to the headstock where a lever in front of the machine enables one of two series to be adopted, according to whether the work of the moment is roughing or finishing, thus making six speeds in all. The feeds are again by independent screws in front of the lathe. Four rates of feed, from $\frac{1}{2}$ in. to $\frac{1}{16}$ in. per revolution, are provided; they are changed from the front of the machine, the gear-box being at the back below the headstock. The feeds can also be started, stopped or reversed from the same point. The saddles have quick hand traverse. Hand feed to the tool slide enables surfacing to be done. The tool post will take four tools

AUTOMATIC MACHINES.

The range of automatics shown at the exhibition is very considerable, and it is impossible for us to deal with more than a few selected examples. A machine of this class with a good output is the piston and piston-ring automatic, of which we give an illustration in Fig. 74, Plate XXXVIII. This is exhibited by Messrs. Thomas Ryder and Son, Limited, of Bolton. The largest work it can take

is about 8 in. in diameter and 10 in. long in the way of pistons. It will turn the outside, cut the ring and oil grooves and face the top end, of a 4-in. piston in 8½ minutes; a 3-in. piston in about 3 minutes, while one 7 in. in diameter and 12¼ in. long can be finished in 40 minutes. It will also bore, turn and part off rings at a rate, for 4-in. rings, of 1 per minute; 6-in. rings, 1 every 2 minutes. The main drive is by fast and loose pulley, through a geared head to the hollow spindle, running in cone and ball bearings. The main saddle has hand and power traverse. For work on pistons the front slide carries roughing and finishing tools, and the back slide the grooving tools and a facing tool for the end. For piston ring work the front tool slide carries the turning tools; the back slide carries 18 parting tools, while a boring bar carried in a rest on the saddle and with its other end held in a pilot bush in the spindle, cleans up the inside. The front slide can be given a reciprocating motion by an eccentric on the shaft seen at a level with the bed. The degree of eccentricity can be raised from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. by 40 intermediate steps, so that a wide range of rings can be cut. The parting and grooving tools always work on surfaces already cut over.

On piston rings the turning and boring tools commence work together, and then the parting tools come in in succession. When the turning and boring is completed, the feed stops, but the parting tools continue cutting till the last is cut off. This motion then also stops. The saddle and back slide are then run back by the large hand wheel to its initial position, the slides keeping in register with each other. In work on pistons the outside is first turned by the front slide and the grooving and facing tools are then brought into action from the back, a roller steady on the front rest counteracting the thrust on the work. Pistons are held on a spigot nose by a pin through the gudgeon-pin hole, and an eyebolt passing through the spindle of the machine and held by nut and washer at the back end.

A very notable machine is to be seen in the form of a new design of large automatic lathe, at the stand of Messrs. Alfred Herbert, Limited, Coventry. This embodies many of the firm's well-known features, but worked out in a new way. Front and back views of this machine are shown in Figs. 101 and 102, page 348, while Fig. 84, above, gives a view of the cam drum operating the turret. The machine is provided with a single pulley head. At the back of the machine is a feed shaft driven at constant speed, and in the bed casting under the head and slides, is the usual camshaft. The latter shaft operates, by means of the drum under the head, clutches for the spindle speeds. The next disc cam operates the front and back slides, which are independent. The turret cam drum is driven by gearing off this shaft in the bed, as shown in Fig. 84. At the right hand end of the machine are the feed cam discs.

The head has a longitudinal adjustment of 6 in. to allow for different thicknesses of work. This is a setting-up adjustment. Other length adjustments are allowed for in setting the tools in the turret. The spindle has six substantive spindle speeds, by means of change wheels, for each of which combinations there are five automatic changes. Three pawl levers actuated by the drum under the head control the head clutches which give different speeds, or cut-out, stopping the machine. These changes can be effected at any point while the machine is running, automatically or by hand.

The cross-slide operations are similar to previous Herbert automatics and need no further description. The slides are independent, and have longitudunal traverse of 7½ in. for setting up. They can be set to operate simultaneously or separately as required, the maximum feed being 4½ in. The turret operation is completely new. The turret slide has a constant travel of 13 in. With the usual cam drum a long travel involves a large diameter drum and consequently a machine of an inconvenient height. With the new arrangement, as will be seen from Fig. 84, a comparatively small drum is used, allowing the machine bed to be only 3 ft. 4 in. high to the spindle, or about the height of an ordinary engine lathe. The drum performs two operations. The left-hand portion is cut with helixes which give the forward and return feed to the turret slide. The right-hand portion operates a secondary slide, which comes into operation when the turret slide is at rest in its extreme back position, and causes the turret to revolve. This helix of the cam drum makes three complete revolutions for each forward and return movement, giving a very regular feed free from vibration.

The feeds give a range of seven changes which can be brought into action at any part of the cycle by adjustable pegs on the disc on the extreme right of the machine. These pegs knock up pawl levers which cause one or another of seven fingers to project and engage a sliding cam on the back shaft. The longitudinal movement of this cam causes different gears to engage in the feed-change box. The cam, after a complete revolution, returns the pin to its disengaged position, when another feed may be selected by another peg engaging with another lever. These levers are interlocked by a number of balls in a row. When a lever is knocked up by a peg, a spacer rises between two balls and separates them. The other levers then each have a ball exactly over them so that they cannot be raised till the one is lowered and the balls are again free to move to one side or the other. In order to prevent pegs for different feeds being inserted in the same dog on the feed disc, these dogs are provided with seven holes covered with a sliding gate with holes out of register with those in the dog. When one peg is inserted in one hole in the gate and dog, all other holes in the dog are fouled. The quick return of the turret is at a constant speed of 19·5 ft. per minute derived from the constant-speed back shaft. The cross-slides also have seven feeds controlled in the same way as the turret feeds. All feeds can be changed automatically while the cut is on.

The overhead arm and lock to the turret, a feature of Messrs. Herbert's previous automatics, are abolished in the new machine, the lock being arranged underneath. There is now no limit to the height of the turret equipment. The turret takes four sets of tools. An overhead sliding arm support is used with most of the tools carried from the turret fixture to the headstock. The bracket on the latter for this is not shown in our views of the machine. The total time occupied by one cycle at high speed, is 48 seconds, the time taken to rotate the turret one station being just over 1 second. The maximum distance from turret face to spindle flange is 34 in. The maximum diameter of work possible over the cross-slides is 16 in., and swing over the ways 18 in.

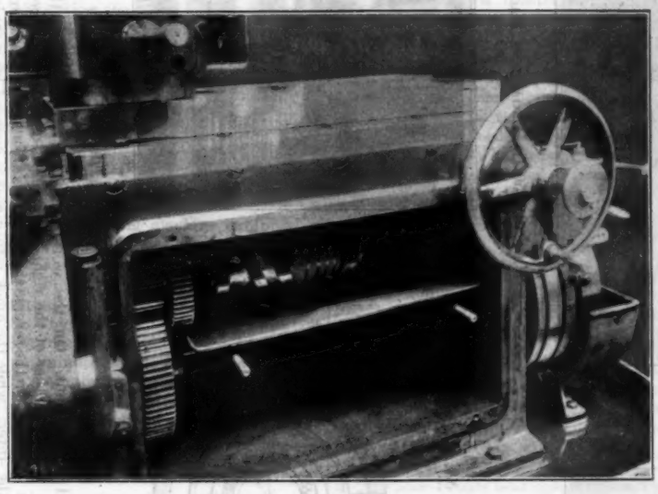


FIG. 84. TURRET CAM DRUM OF AUTOMATIC LATHE; MESSRS. ALFRED HERBERT, LTD.

BROACHING MACHINES.

With the large development in broaching which has taken place in recent years it might have been expected that this class of work would have been rather more to the fore at the exhibition than is actually the case. Several machines are certainly shown, but they do not exhibit very striking innovations in design, though all can claim improvement of a useful character. We illustrate on page 340, in Figs. 85 to 90, two such machines. The one is by Messrs. Smith and Coventry, Limited, of Manchester; the other is by Messrs. Alfred Herbert, Limited, Coventry. The Smith and Coventry machine, Figs. 85 to 88, is of the usual general form, but the gear-box is interesting in that the gears are engaged by friction cone clutches instead of sliding on keyed shafts. Only one speed is provided forward and a quick reverse. The gears run loose on the main sleeve containing the draw-nut, the corresponding clutch members being fixed to the main sleeve. The wheels are moved in one direction or the other, only one engaging at a time, by the lever shown at the side of the bed near the operator's position. The stroke of the machine is 42 in. and the diameter of the screw 2½ in. The largest broach shank taken is 1¾ in. The broaches are gripped in a special chuck which is shown in Figs. 86, 87 and 88. This consists of a chuck ring which can be screwed in or out on the crosshead on the end of the draw-screw. Inside the chuck ring is a loose cone ring, inside which again are four segmental cone pieces kept as far as possible apart by small springs set between them. The action is evident. When the chuck ring is rotated so as to force it further on to the crosshead the cone ring forces the segments together. The broach end instead of being made with the usual cotter or screwed end, is formed with a neck and shoulder, as shown in Fig. 86, and the segments grip the broach under this shoulder. Centring pins are set in the chuck ring, and if necessary can be set slightly out of centre to meet special conditions. The eccentricity thus allowed is ¼ in.

The gears and screw run in an oil bath, and the ball thrust bearing and nut are kept flooded by pump. During the return stroke the oil pump does not operate. The projecting screw during withdrawal is covered by a tube which also serves the purpose of returning excess lubricant to the oil-bath casing. The machine is fitted with an automatic trip operated by dogs on the bar seen on the far side of the bed. It may be mentioned that screwed or cottered broaches can still be used with this machine by means of adapters made by the firm.

Messrs. Herbert's is a 50-in. machine, intended for all the usual straightforward work of keyway cutting, finishing holes from rough drilling, cutting internal gears, splines, &c. The machine has a single pulley drive to a gear-box shown at the far end of our view, Fig. 89, page 340. This view is of the back of the machine. On the other side there are two levers, one of which is seen near the operators end of the trough; the other is, out

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

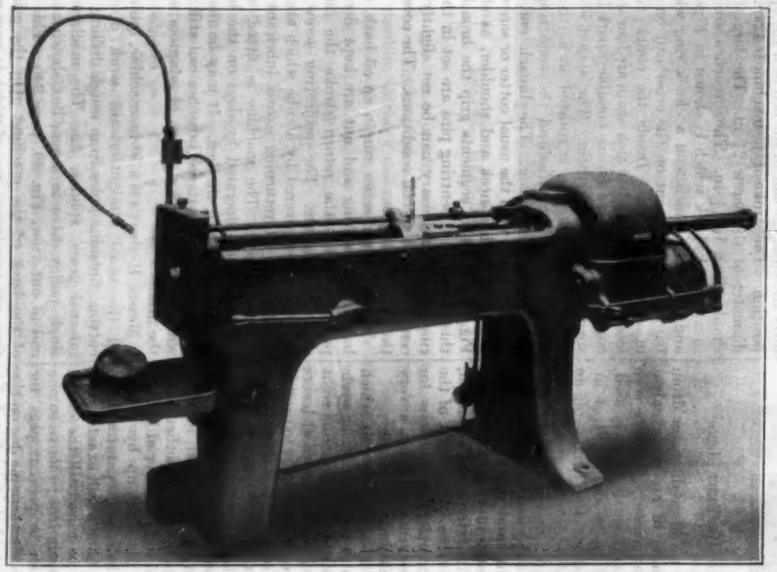


FIG. 85. 42-IN. BROACHING MACHINE; MESSRS. SMITH AND COVENTRY, LTD.

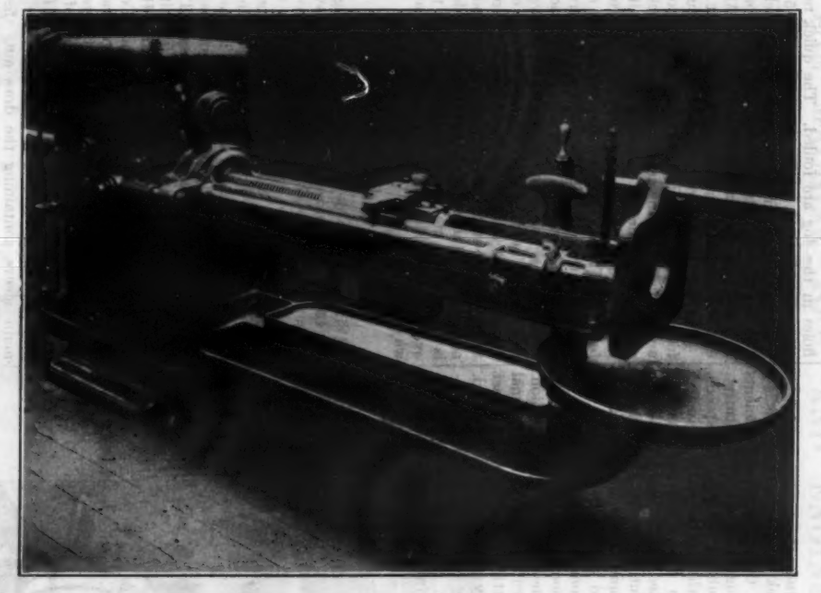
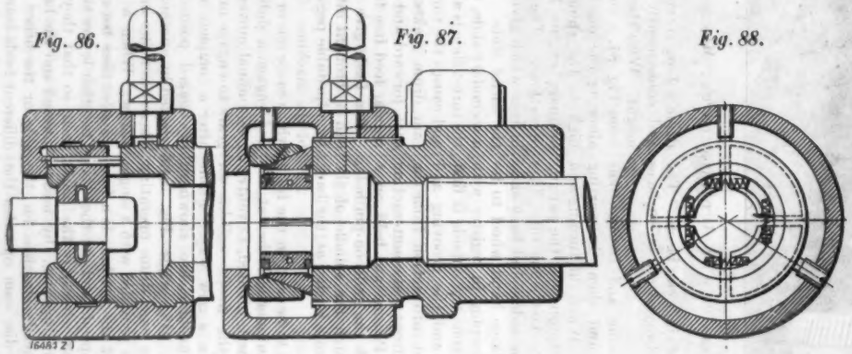


FIG. 89. 50-IN. BROACHING MACHINE; MESSRS. ALFRED HERBERT, LTD.



FIGS. 86 TO 88. CHUCK OF SMITH AND COVENTRY BROACHING MACHINE.

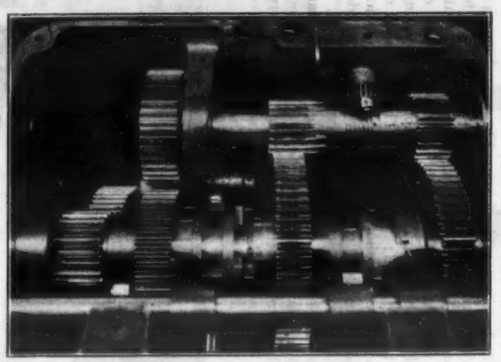


FIG. 90. GEAR-BOX OF HERBERT BROACHING MACHINE.

of sight on the front side of the gear-box, being, in fact, the gear-change lever. The interior of the gear-box is shown in Fig. 90, page 340. In this the single pulley spindle is the one at the top of the picture. This spindle has three gears on it. The small one to the right gives the 4-ft. per minute cutting speed. The still smaller one in the middle is for a cutting speed of 3 ft. per minute, while the rather larger one at the left-hand end of this shaft is for the quick return at the end of the stroke. The drive is through double-reduction gear, with dog clutches on the intermediate shaft. The drive from the intermediate shaft to the draw-screw is through the pair of gears at the left hand end of the box, the large gear which is partly hidden being on the draw-nut. On the working stroke either one or the other of the right-hand sets of gears are engaged. On the reverse these two sets are unclutched and free, while the quick return gear is engaged by a conical friction surface. The sliding clutch is controlled by the lever already referred to near the operator's position. When this lever is brought into the neutral position a brake is applied automatically to the drawhead to bring it quickly to rest. The return speed is 11 ft. per minute. The pulley spindle and intermediate shaft run on ball bearings and the idle gear for the reverse train is similarly fitted. All gears are case-hardened high-tensile steel. The screw spindle runs in white metal bearings. The phosphor bronze nut on the draw-screw is 9¾ in. long, the screw having a diameter of

2¾ in. The free end of the screw is protected by a tubular guard. The thrust of the screw is taken by a large ball bearing; when on the return stroke the thrust is taken by a white metal washer. The draw-head is a steel forging, coupled to the screw by a large dowel. It has a vertical slide, adjusted by screw and knurled handle, to which the broach is fitted.

The length of the stroke is regulated by adjustable stops on the side rod shown in our illustration at the back of the machine. This serves to throw out the clutches at any required points. A bracket projecting from the draw-head carries a pin which actuates these stops. The machined vertical face of the end of the bed has a central hole in which can be fitted bushes or flanges carrying fixtures. The rod projecting from this plate is used for suspending supports to long work. It is removable.

The gear-head is lubricated by a small plunger pump driven by the worm and wheel shown on the pulley spindle in Fig. 90. This pump delivers oil to a flat tray placed over the gears, and perforated vertically over all essential points, so that a constant stream of lubricant is carried into the working parts. A pump for lubricating the work is driven by belt from a pulley outside the main pulley. The chippings and lubricant fall into the larger pan below (which can be swung clear if desired) and from there the lubricant is drained back to the pump at the other end of the machine. The single pulley is 16 in. in diameter and is for a belt width of 5 in. It runs at 400 r.p.m. and the machine requires 10 h.p. The machine will broach keyways 3 in. wide, or cut holes 3 in. wide across the flat from round holes, in steel.

Another British broaching machine exhibited is that by Messrs. Vickers, Limited, which is shown by Messrs. Charles Churchill & Co., Limited, Leonard-street, Finsbury, E.C. 2. This machine has an interesting return arrangement controlled by a cam plate which moves over a separate belt driving the return mechanism. These speeds are 3 ft. to 6 ft. per minute on the forward stroke and 35 ft. and 55 ft. per minute on the return, according to the machine. The thrust of the screw is taken on a roller bearing. The train of gears working the screw on the forward cut is not reversed. The machine can be controlled from both sides, and the length of stroke can be varied by adjustable stops which operate the cam plate above referred to.

Drilling Machines.

A series of very workmanlike looking drilling machines of various types and sizes is to be seen on the stand of Messrs. Frederick Pollard and Co., Limited, of St. Saviours-road East, Leicester. Three of these are illustrated on Plate XL. The first with which we will deal, that shown in Fig. 91, is a three-spindle gear-driven sensitive drill. The column is of wide box section and carries a table with tee slots raised and lowered by a screw in the usual way. The 1 in. diameter spindles are made from the solid and are spring balanced. Each is fitted with two driving keys. The feed levers are adjustable and the racks are fitted with adjustable stops to regulate the depth of hole drilled. The driving pulley runs at 450 r.p.m., and there are four spindle speeds varying from 385 r.p.m. to 1,092 r.p.m. The distance between the spindles is 9 in., and from spindle centre to column face 7⅛ in. Fig. 92 shows a 27-in. upright drilling machine. This tool has a maximum space between the spindle nose and the table of 32 in. and between the spindle nose and the base of 48 in. The vertical movement of the spindle is 12 in. and the distance from the spindle centre to the column face 13⅜ in. With the main pulley running at 400 r.p.m., there are eight spindle speeds varying from 21 r.p.m. to 290 r.p.m. There are six feeds varying from 28 to 178 per inch. The friction clutch back-gear is operated from the front of the machine. There is also a reverse motion which has a speed gain of 2 to 1. The feed is instantaneously engaged through a friction clutch cross axle. The various feeds are obtained through sliding steel gears.

The third machine of Messrs. Pollard's make which we illustrate is a 36-in. all-geared radial drilling machine. A general view of the machine is given in Fig. 93, while a view of the sliding head showing the controls is given in Fig. 94. The machine will drill up to 1½ in. in steel and has a 1½ in. diameter spindle. The vertical movement of the spindle is 12 in. and there are nine speeds varying from 51 r.p.m. to 750 r.p.m.. There are four spindle feeds, from 53 to 177 per inch. The working surface of the table is 34 in. by 26 in., and the maximum distance between the spindle end and the table is 24 in. The table has a vertical range of 12 in. The gear box is of the sliding-wheel type with steel wheels running in oil and giving nine spindle speeds as stated above. The spindle has two driving keys and a ball thrust and runs in a steel rack bush lined with gun-metal and graduated in sixteenths of an inch. The cross-axle is fitted with a friction clutch which enables the feed to be engaged instantly. The change-feed mechanism is also through sliding steel wheels. Bearings are gun-metal lined and are of the self-oiling type. The machine weighs 2,500 lb.

Power Saws.

The last section we will deal with this week covers a number of power saws of various types. The first which is illustrated in Figs. 95 to 97, on Plate XLI, is a circular cold-sawing machine made by Messrs. Alfred Herbert, Limited, of Coventry. The machine will saw round bars up to 6 in. diameter and square up to 5½ in. It will also deal with rectangles 12 in. by 4 in. or 10 in. by 5 in. The saw is 20½ in. diameter and runs at 12 r.p.m. The feeds range from ⅛ in. to 2½ in. per minute. The horse-power required is 7, and the floor space occupied, exclusive of projecting bars, is 7 ft. 7 in. by 5 ft. 2 in. The machine consists essentially of a box bed with planed seating, on which are mounted the pulley bracket, the head, the vice and the stock stop. It has a gutter round its outer edge for collecting the cutting compound and returning it to a tank inside. The cutting compound pump and a removable chip basket are contained inside the bed. The pulley bracket, which is attached to the bed, as can be seen in Fig. 96, carries the phosphor-bronze nut for the feed-screw as well as the main pulley bearing and belt-shifting mechanism. The head which slides on ways bolted to the top of the bed contains the saw spindle and all driving and feed mechanism. The saw spindle, which runs in phosphor-bronze bearings, is driven by a hardened steel gear and pinion, the pinion in turn being driven by a worm wheel actuated by a worm on the main shaft. The thrust of the worm is taken by a large ball thrust bearing.

The feed changes are obtained from the four step cone pulleys which can be seen in Fig. 95. The head has an automatic quick return to withdraw the saw after cutting-off. The adjustable feed stop throws in the quick return and another adjustable stop regulates the position to which the saw returns. The vice has both vertical and horizontal jaws and is suitable for gripping most sections. Two vice handles are provided. The stock stop is strong and positive. The saw is of the inserted tooth type with high-speed steel teeth. The makers state that such a saw proves to have a much higher output than any solid saw. The inserted teeth have radial and circumferential clearance, and although the built-up saw is a little thicker than the solid saw, it is stated that there is less waste of material since the saw cuts more squarely.

The feature of greatest interest in the machine is the patent chip remover which is illustrated in Fig. 97. As will be seen this is of an extremely simple nature, and the reflection which is induced by seeing it is a wonder that it has never been invented before. It consists of a disc of case-hardened steel fixed at right angles to the saw and having teeth which gear with and are driven by the saw. The teeth are so shaped that they give a scraping action across the teeth of the saw. This action effectively removes all chips from between the saw teeth. They fly out with considerable force and the disc is provided with a cover enclosing it. This cover not only catches the flying chips, but also acts as a brake in the movement of the disc and ensures close contact between its teeth and the cutting surfaces of the saw teeth. The effect of the use of this chip remover is to enormously reduce the breakage of saw teeth and to enable much higher speeds to be run without risk of breakage. Messrs. Herbert state that their experience is that the inserted tooth saw fitted with their chip remover will do four times the work of an ordinary saw without the chip remover.

Of the remaining machines we have to mention this week the first two are power driven hack saws, and are shown in Figs. 98 and 99, on Plate XLI. The first of these figures shows a small tool of a capacity up to 3-in. bar, which is exhibited by Messrs. Charles Wicksteed and Co. (1920), Limited, of Stamford-road Works, Kettering. It is intended for small works, garages, &c., and is produced to meet a demand for a small but powerful machine which will cut without the saw running off at an angle. The tool shown in Fig. 99 is known as the "Vilvalle," and is exhibited by Messrs. W. A. Walber and Co., of 38, Victoria-street, Westminster. It is a heavy-duty machine, and is fitted with a pump and tank for cooling compound. It will cut up to 20 in. square at two settings. The arrangement of guides is carefully worked out to ensure alignment, and the blade is lifted on the return stroke by an arrangement which lowers it gradually on to the work at the beginning of each cutting stroke. The final machine to which we have to refer this week is a small band saw which is to be seen on the stand of Messrs. Blacker, Limited, of Stayley Ironworks, Stalybridge. The frame is of a pillar type, the top arm and wheel being balanced by a weight passing down the pillar. They are raised and lowered by wheel and pinion engaging a rack on the pillar and considerable variation in the length of the saw can be accommodated. The guard is a novel feature. It is hinged on the main pillar and can be swung out of the way in a second or two. The machine will cut 12 in. deep, and the diameter of the wheels is 24 in. The tool should be very handy for patternmaking.

(To be continued.)

INDUSTRIAL NOTES.

The Trades Union Congress opened at Portsmouth last Monday, when Mr. J. H. Thomas, M.P., delivered his presidential address, an epitome of which we give below.

There are at the present time in this country labour difficulties of exceptional gravity. The threatened coal strike, if it occurs, will most assuredly disorganise entirely, if it does not ruin, our industry and commerce. Quite apart from this, a deadlock has occurred in the engineering trades through the action taken with reference to a single foreman employed at Messrs. Cammell Laird and Co.'s Penistone Works. The printers are on strike at Manchester and Liverpool, and other labour troubles are threatening at other parts. Yet, in his presidential address to the Congress, Mr. Thomas did not refer to any of these difficulties. The whole proceedings of the first meeting reminded us very forcibly of the action of certain municipal councils who, instead of dealing with the municipal matters they are appointed to see carried through, and carried through as economically as possible consistent with thoroughness, spend their time in passing votes of censure on Government.

In opening his address, Mr. Thomas stated that looking at the position to-day both at home and abroad, he would indeed be an optimist who could find occasion for anything but apprehension. "We have gone through," he said, "during the last few weeks what is the most momentous period of the trade union and labour movement in our long history, a period which found for the first time a united and determined working-class effort to challenge the existing order of Parliamentary Government." After dealing with Ireland, Russia, Mesopotamia and other matters which are outside our scope, Mr. Thomas stated that every available evidence tended to show that the coming winter would, in many respects, be the hardest experienced in this country for many years. Already there were thousands of unemployed, and there were clear and unmistakable signs of a break in the trade boom. Further, in several industries steps were being taken to consolidate the capitalists' interests, and there was abundant evidence of a growth of trusts and combines. Indeed, he added, some had not hesitated to say that a fight was necessary, and were preparing accordingly. He did not believe the workers were anxious for a fight merely for fighting sake, "but 'the other side' must clearly understand that the years of sacrifice and effort that placed the worker in the position he holds to-day will not and

must not be lost, and we will be prepared, not as a section but as a movement, to accept any challenge to our industrial freedom and economic emancipation." During the past year, Mr. Thomas also said, the relationship between the different unions and their dependence one upon another had been strikingly illustrated. A dispute in one particular union spread rapidly and affected not only other workers in the same industry, but also workers in other unions who had no voice whatever in the dispute. There had been also many illustrations of the effect of a request for sympathetic support from unions which had not been consulted regarding the dispute, this leading to bad feeling and suspicion. "These were matters which were calculated to weaken our efforts and to dissipate our strength and give cause to 'our opponents' to point to our weakness and inability to control our own affairs." The use made by Mr. Thomas of the terms "the other side," and "our opponents," illustrate the persistent antagonistic attitude taken up by Labour against Capital. He referred also, as might have been expected, to the Government's policy with regard to the Lord Mayor of Cork, a matter which he said was one of urgency. Housing, rents and other questions were considered in the afternoon sitting.

The Trades Union Congress resumed its sittings on Tuesday, Mr. J. H. Thomas, M.P., again occupying the chair. The members dealt with the question of Friendly Societies and the administration of unemployment benefit; consideration of the subject was deferred until a definite motion came before the Congress. The following resolution was moved by Mr. Clynes, M.P.: "That this Congress condemns the failure to acquire the war wealth into which special inquiry was made by a responsible committee, and declares that conditions of national finance, taxation and price require an immediate capital levy. Congress is of opinion that the interest on the national debt is such an enormous burden on the industry of the country that it will inflict serious hardship upon the working classes by diminishing the purchasing power of wages, while it will enrich financiers, who will derive large permanent incomes; we therefore urge the Government to impose a levy upon wealth and capital to pay off the great war debt and relieve labour from the misery which must be inflicted upon future generations by extracting from wages the amount demanded in interest on the debt, and urge the Parliamentary Committee to press forward this demand upon the Government." The resolution was carried unanimously.

The Congress continued its sittings on Wednesday, and in opening the proceedings Mr. Thomas referred to the deliberations which the railwaymen and transport workers had held concerning the miners' claim; both, he added, unanimously arrived at the conclusion that the miners' claim was not only fair and reasonable, but that it showed a peculiarly unselfish attitude on the part of the miners in combining their demand for an increase in wages with a decrease in the selling price of coal. After dealing with Russian "trade union" delegates and questions of currency, Mr. F. Hodges put before the meeting the miners' case and the following resolution: "That this Trades Union Congress having heard the statement of the miners' case for the reduction in the price of domestic coal by 14*s.* 2*d.* per ton, and an advance of wages of 2*s.*, 1*s.*, and 9*d.* per shift for adults, youths and boys respectively, is of opinion that the claims are both reasonable and just and should be conceded forthwith." The resolution was passed unanimously, Mr. Thomas adding that that was the message the Miners' Executive were taking to London.

Last Tuesday, Sir Robert Horne, President of the Board of Trade, telegraphed to Mr. Smillie as follows: "In order to avoid any misunderstandings as to our respective points of view, I should be glad if you would bring your executive to the Board of Trade on Thursday next, the 9th inst., at 11 a.m., to discuss the present position." It is stated, on behalf of Sir Robert, that he thought it desirable that the present position be clearly stated, in view of statements which have been made in the press from both sides; hence his above telegram to Mr. Smillie. In an interview which Sir Robert had earlier in the day (Tuesday) with the press, he made it clear that upon the question of policy the Government could not accept the dictation of any section as to the price which was to be charged for coal. In the matter of the miners' wages, however, the Government were of opinion that an increase was not justified, but there was a regularly constituted court, the Industrial Court, instituted for dealing with such questions, and the Government were entirely willing to have the point determined by the said court. On Tuesday also, but probably earlier in the day, Mr. Frank Hodges, the secretary of the Miners' Federation, said the following:—

"In view of the statements made in the Press that no answer has been forthcoming from the Miners' Federation of Great Britain to a certain proposal or proposals made by Sir Robert Horne, it is necessary to state clearly—

"1. That no communication of any description whatsoever has been sent to the Miners' Federation of Great Britain by Sir Robert Horne.

"2. That it is customary to communicate direct to the accredited officials of unions any new proposals.

"3. That, when received, such proposals are seriously examined by the Executive or Negotiating Committees, and the answer thereto is the considered answer of the responsible body, and not an individual opinion.

"4. That the claims of the Miners' Federation are the same to-day as they were when first formulated and made known to the Government.

"5. That all notices expire on September 25."

The above information would seem to point to a settlement being as distant as ever.

A conference was ultimately arranged at the Board of Trade for 11 a.m. on Thursday, when Sir Robert Horne met the miners' representatives. The meeting lasted two hours, but no settlement was reached. Sir Robert Horne repeated his decision that the question of the price of coal could not be considered, but that of wages should form the subject of an inquiry before the Industrial Court. Mr. Smillie said the miners were not prepared to go to the Industrial Court. Subsequently Mr. Smillie stated that no suggestions were made at the conference which was likely to lead to a solution.

The report of the twenty-first annual general council meeting of the General Federation of Trade Unions, held in the Town Hall, Leamington, on July 1 and 2, of the current year, states the following, on page 37: Mr. Bailey (Leicester Hosiery Union), referring to remarks made by Mr. Bell (National Amalgamated Union of Labour), said: "I have seen working men who have been employing a small amount of labour and who have ground them down far more than any large employer of labour dare do. I do not think we ought to throw stones about that. We are all grabbing all we can, and sometimes the working man grabs more than the capitalist."

The following is the copy of a letter which was forwarded last Monday to all the leading manufacturers and trade manufacturing associations in the United Kingdom:—

"It has been suggested in certain quarters that in the event of a coal strike manufacturers throughout the country should promptly close down their works in order to put pressure upon the coal miners and to prevent funds from reaching them from other unions. In our opinion this course would be in the highest degree undesirable.

"It must be remembered that the quarrel is not one between the miners and their employers, but is a direct challenge of the policy of the Government. The manufacturers of the country and the innocent workers in other industries are equally threatened by such a strike, which must involve all in heavy losses and serious unemployment, since few firms will be in possession of coal supplies sufficient to carry on for more than a very short period.

"It seems, therefore, to be the plain duty of employers in this national crisis to keep open their works as long as possible, in order to mitigate the hardships which must result from the strike to the community at large.

"The dangers and difficulties of the situation must inevitably be very great, but they cannot fail to be aggravated by every addition to the ranks of the unemployed."

The letter is signed ALLAN M. SMITH (Chairman), National Confederation of Employers' Organisations, and W. PETER RYLANDS (President), Federation of British Industries.

The electricians' lock-out referred to in our last issue is now in operation. Correspondence has been exchanged between Dr. Macnamara, the Electrical Trades Union and the Engineering and National Employers' Federation. Mr. J. Rowan, the general secretary of the Electrical Trades Union, wrote to Dr. Macnamara saying that ". . . conditionally upon the Engineering Employers' Federation withdrawing the lock-out notices pending the inquiry, we are prepared to instruct our members to return to work at Penistone." Mr. J. Brown, secretary of the Engineering and National Employers' Federation, wrote on the 7th inst. to Dr. Macnamara as follows:—"I am desired by Sir Allan Smith to acknowledge receipt of your letter of September 5, 1920, with reference to the dispute with the Electrical Trades Union. I note your decision to institute an inquiry under the Industrial Courts Act. I also note that you suggest that the lock-out notices should be suspended pending the report of that inquiry. While appreciating the motive which has prompted you to make the suggestion regarding the suspension of the lock-out notices, I am desired to say that it is one with which the Federations are unable to comply. I am desired to remind you that the question at issue has been the subject of negotiations with the Electrical Trades Union and other unions interested at conferences every week for over a month, and that at our meeting yesterday afternoon Mr. Rowan, the general secretary, stated on behalf of the Electrical Trades Union that unless a settlement was arrived at on the basis of their proposal at the first conference with the employers, no agreement was possible, as the difference between the parties is a fundamental one."

It is reported that Sheffield members of the Electrical Trades Union do not in the least endorse the policy of their executive.

The Home Office state that a Safety and Welfare Committee, which was set up by the Building Trade Joint Industrial Council in February, 1919, to consider the working conditions in that industry, and which was joined by representatives of the Furniture and Saw Milling Industries, has conducted a careful investigation into all dangers attendant on the use of woodworking machinery, and has submitted a series of important recommendations in regard to the fencing of the most dangerous types of such machinery. A report, which has been unanimously adopted by the Building Trade Joint Industrial Council, has been issued. In this report, the committee suggests that the Secretary of State should give legal effect to the recommendations by means of regulations. The Secretary of State has approved this suggestion and has certified woodworking machinery to be dangerous, and proposes to make regulations as in a draft which has also been issued. If any person desires the regulations as in this draft to be further considered, he should lodge objection in accordance with Section 80 of the Factory and Workshops Act, 1901. Copies of the draft may be obtained on application to the Factory Department, Home Office, London, S.W. 1. Any objection with respect to the draft regulations must be sent to the Secretary of State within 40 days from the 3rd inst.

The British Commonwealth Union report that on July 17, 1920, the number of persons engaged in the building and construction of works, as shown by the number insured against unemployment, was 938,971 (of whom 4,014 were females), a total 50,208 higher than on April 16, while the number out of work on July 30, as indicated by the lodging of unemployment books and out-of-work donation policies (ex-service men and women), was 20,575, or 2·19 per cent. Of these, 73 were females.

According to *The Labour Gazette* for March, 1914, the total number insured against unemployment in the same trades on January 17, 1914, was 936,923, so at the present time there are 2,048 more insured than in January, 1914.

At the present time in the two trades most required in the building of houses, viz., carpenters and bricklayers, there is only nominal unemployment, as the few who are out of work will be merely those who are temporarily unemployed for some purely personal reason.

Out of the 20,575 who are unemployed, it appears that 15,838 are seeking work in the trades concerned, and the remaining 4,737 though insured in the building trades are seeking work in some other trades.

The latest pre-war date at which employment in the building trade was unaffected by the great building strike was the end of December, 1913, when 6·9 per cent. of those insured were out of work.

As, however, the building trade is a seasonal trade, it is better to make comparison on corresponding dates, and therefore comparison should be made with July 31, 1913, when the percentage was 4 per cent.

In view of these facts, it is difficult to see why there should be restriction of output or resistance to dilution on the part of the building trade operatives.

THE LONDON IRON AND STEEL EXCHANGE, LIMITED.—Continental iron and steel material is being quoted for export to Great Britain and other markets at figures which decrease almost week by week, this being an indication that foreign competition is actually materialising, and British manufacturers would do well to prepare to meet it when market conditions in this country improve.

BRITISH INDUSTRIAL "SAFETY FIRST" ASSOCIATION.—This association, whose address is 2 and 3, The Sanctuary, Westminster, S.W. 1, announce that a conference is to be held on the 22nd inst., on safety, safeguarding machinery, first aid and hygiene, in the Conference Hall, Olympia, West Kensington, W. 14. At the morning session, from 10.30 a.m. to 1 p.m., the Right Hon. Edward Shortt, K.C., M.P., Home Secretary, will preside, when three papers will be read and discussed. The afternoon session, from 2.30 p.m. to 5 p.m., will be presided over by the Right Hon. Lord Leverhulme, when six papers will be read and discussed. Particulars of the conference can be obtained from the association.

AIR MINISTRY COMPETITIONS, 1920.

TABLE OF DATA REGARDING THE LARGE AND SMALL AEROPLANES ARRANGED ALPHABETICALLY IN EACH CLASS.

Name.	Horse-Power. Nominal and Type of Engine.	Horse-Power. Actual.	Area. Sq. Ft.	Weight in Pounds. Total. Empty (including Water).	With Fuel.	Performance tests.	Reliability Test.	Certificate of Air Worthiness.	Useful Load. Performance Test.	Reliability Test.	Fuel used in 7 Hours' Cruising. Petrol. Total.	Oil.	W / G. (a)	Speed in M.P.H. Cruising. Indicated.	Actual. (b)	High. (b)	Low. (b)	"Get Off" Feet above Ground. (c)	Landing, Yards from Mark.	Pounds per Horse-Power. Total. Performance Tests	Reliability Test.	Useful Load. Performance Tests.	Reliability Test.	Pounds per Square Foot. Performance Tests.	Reliability Test.
LARGE AEROPLANES.																									
Central Aircraft "Centaur"	2—160 Beardmore	354 at 1,250 rpm	905	4,996	5,840	7,250	7,250	7,250	1,210 (d)	1,210 (e)	148·5 11·0 159·5		7·6 (d)	61	63	89	48	0	281	20·48	20·48	3·42 (d)	3·42 (d)	8·10	8·10
Handley Page "W.8"	2—450 Napier "Lion"	1,008 at 2,200 rpm	1,456	7,850	9,843	11,443	12,500	12,500	1,400 (e) 1,618	2,675	279·0 9·0 288·0		9·2	84	88	119	55	74	263	11·35	12·40	1·60	2·65	7·86	8·58
Vickers "Vimy Commercial"	2—350 Rolls Royce "Eagle"	704 at 1,800 rpm	1,335	7,700	9,257	11,057	11,057	12,500	1,600	1,600 (f) 2,060	240·0 12·75 252·75	(f) 294·0	6·3 (f) 9·7	80	84	103	50	26	308	15·71	15·71 (f) 17·75	2·27	2·27 (f) 4·06	8·28	8·28 (f) 9·80
SMALL AEROPLANES.																									
Austin "Kestral"	160 Beardmore	177 at 1,250 rpm	417	1,966	2,321	2,721	2,740	2,740	200 (g) 181	219 (g) 200	63·55 3·725 67·275		3·0 (g)	81	83	110	45	14	244	15·37	15·48	•1·02	1·15	6·52	5·57
Avro Triplane	230 Siddeley "Puma"	245 at 1,400 rpm	498	2,460	3,064	3,683	3,683	3,666	419 (i) 397	419 (h) 402 (i) 380	105·0 4·5 109·5		3·7 (i) 3·5	79	83	96	51	1	239	16·03	14·96	1·62	1·55	7·39	7·36
Bristol	230 Siddeley "Puma"	245 at 1,400 rpm	566	2,654	3,190	3,590	3,591	3,590	200	200	85·0 5·18 90·18	(k) 88·58	2·2 (k) 2·4	82	86	108	49	10	314	14·65	14·65	0·82	0·82	6·34	6·34
Sopwith "Antelope"	200 Wolseley Hispano "Viper"	210 at 2,000 rpm	531	2,387	2,817	3,217	3,350	3,350 (l) 3,450	200	333 (l) 433	70·5 7·125 77·625	(l) 83·75	4·3 (l) 5·1	80	84	110	43	23	188	15·32	15·95 (l) 16·43	0·95	1·50 (l) 2·00	6·06	6·31 (l) 6·49
Westland "Six Seater."	450 Napier "Lion"	504 at 2,200 rpm	726	3,023	4,559	5,559	5,852	5,850	800 (m) 840	1,133 (h) 1,131	128·0 3·0 131·0	(m)	(b) 8·6	86	90	118	46	23	235	11·03	11·61	1·61	2·24	7·66	8·06

(a) Weight of useful load carried on reliability trial divided by the gallons of fuel consumed—given to the nearest figure in the first place of decimals. The useful load is obtained by deducting from the total weight of the machine, as on the test, its weight with fuel for 450 miles at 80 m.p.h., but without load, and a weight of 200 lb. to represent the pilot and his gear. (b) Shown to the nearest mile. (c) Shown to the nearest foot. (d) This machine carried only enough fuel for 315 miles at 63 m.p.h. These figures are not therefore comparable with the similar figures for the other machines. (e) Includes an allowance of 218 lb. for excess fuel carried. (f) These figures show the estimated results if the machine had been loaded up to the full certificate weight for the reliability trial. (g) Includes a deduction of 19 lb. for short fuel carried. (h) Corrected to certificate of airworthiness weight. (i) Includes a deduction of 22 lb. for short fuel carried. (k) Actual duration of reliability test was 7 hours 5 minutes. These figures are corrected to 7 hours. (l) These figures show the estimated results if the machine had been loaded up to the full certificate weight, which was increased by 100 lb. after the reliability test had been carried out. (m) Includes an allowance of 40 lb. for excess fuel carried. The reference letters refer to the figures directly below them.

GOVERNMENT AEROPLANE COMPETITION.

WE have received from the Air Ministry the table above, giving the data obtained regarding large and small types of aeroplanes taking part in the Air Ministry Competitions at Martlesham Heath. They are arranged in each case alphabetically.

RAILWAYS IN THE MALAY PENINSULA.

In his annual report on the Federated Malay States for 1919, Sir E. L. Brockman (Chief Secretary) gives some information about the railway system. The capital account now stands at 14,429,550*l.*, as against 12,710,081*l.* at the end of 1918. Gross receipts amounted to 1,718,602*l.*, and the net profit earned last year amounted to 386,218*l.* During the past three years, the F.M.S. railways have contributed the sum of 204,755*l.* to the Imperial Government for war purposes.

No new lines were opened for traffic during the year, and the increase in mileage of running lines was inconsiderable. Five new stations and five new "halts" were opened, making at the end of the year a total of 212 permanent and 26 flag stations (or "halts") open for traffic.

The train service in connection with the Siamese Royal State Railways, inaugurated on July 1, 1918, has resulted in the development of a considerable traffic, both passenger and goods, between Siam and Malaya. The passenger service over the Siamese Railways is at present on alternate days, and the time occupied on the journey between Singapore and Bangkok is four days. It is hoped that the service will shortly be accelerated by the running of express trains over the Siamese system.

The statistics of passenger traffic are of considerable interest, especially as compared with those for goods traffic. The receipts from goods trains show an increase of 9 per cent. only (as compared with 1918), while passenger receipts have increased by 17·3 per cent. The relation between the increase of wages and the number of passengers carried is a perfectly well-known phenomenon, and in the F.M.S. the inference is peculiarly well marked by the figures for the percentage increase of passengers of different classes :—

	Per cent.
First class	33·41
Second class	30·56
Third class	11·41

These figures tend to confirm the general impression of the average traveller that there is a steady migration from the third to the second, and still more from the second to the first-class accommodation.

The shortage of locomotives, which so seriously affected traffic during the war, has been partly remedied by the receipt of the fourteen American locomotives, ordered, as explained in the report for 1918, in consequence of inability to obtain supply from the United Kingdom. The average daily mileage per engine during the year was 108·25 as against 110·11 in 1918. In view of the difficulty and delay in obtaining steel trucks from England, 350 trucks of different types were constructed locally of timber. This experiment proved most economical, as, apart from the fact that the locally made trucks were at work and earning revenue during the year, the cost of building as compared with the cost of the imported article represented a saving of 66,700*l.*

Three new steam boats—two stern wheelers and one tug—were added to the railway fleet during the year.

The total expenditure during the year on construction and surveys of new lines amounted to 893,106*l.*, as compared with 274,660*l.* during 1918. Progress was made with the extension of the East Coast Railway, which runs through the State of Pahang and will connect with the Siamese system on the eastern side of the Peninsula. Substantial progress was also made by the contractors with works connected with the new jetty and wharf at Prai (Penang). Reclamation was impeded by difficulty in retaining the dredged materials, but this difficulty has since been satisfactorily dealt with. Work on cylinder sinking for the jetty began in May, and satisfactory progress was made during the remainder of the year. The contract for the construction of the causeway across the Straits of Johore was let in June to the same contractors who are handling the works at Prai referred to above, namely, Messrs. Topham, Jones and Railton, Limited. Considerable progress was made before the end of the year in temporary and preliminary work. The term for completion of all work on and in connection with the causeway is five and a quarter years.

THE PRICE OF PETROL.—In view of the new increase in the price of petrol it is more essential than ever that economies in the running of commercial motor vehicle should be effected wherever possible, and with this object in view the National Council of the Commercial Motor Users' Association has requested all its members to use their utmost endeavours to save petrol, and recommends that (*a*) a bonus shall be offered to drivers based upon present average consumptions, to the extent of half the value of the petrol saved; (*b*) there shall be accompanying instructions to drivers to stop the engine when the vehicle is collecting or delivering, or when a halt (other than in traffic) may exceed 1 minute in duration. The association, in addition to suggesting to the Profiteering Committee of the Board of Trade that this is one of the matters which very properly comes within its terms of reference, is taking active steps in conjunction with the Department of Scientific and Industrial Research and the Empire Motor Fuels Committee of the Imperial Motor Transport Council, to endeavour to bring about an increase in the production of alternative motor fuels.

ROYAL AERONAUTICAL SOCIETY.—The following lectures have been arranged for the next session, commencing on October 7. The lectures will in each case take place in the theatre of the Royal Society of Arts, John-street, Adelphi, commencing at 5.30 p.m. An abstract only will be read in order to permit of a full discussion. Where possible a summary will be published previously in the *Aeronautical Journal*, the full paper and discussion being printed afterwards as heretofore: October 7, Major-General Sir F. H. Sykes, G.B.E., "Civil Aviation"; October 21, Squadron-Leader R. M. Hill, R.A.F., "A Comparison of the Flying Qualities of Single and Twin Engined Aeroplanes"; November 4, Mr. H. Ricardo, "Possible Developments in Aircraft Engines"; November 18, December 2, December 16, Colonel Flack, "The Human Machine in Relation to Flying"; January 20, Lord Montagu of Beaulieu, "The Cost of Air-Ton Miles Compared with other Forms of Transport"; February 3, Mr. G. Dobson, "Meteorology"; February 17, Mr. F. Handley Page, "The Handley Page Wing"; March 3, Mr. J. W. W. Dyer, "Airship Fabric"; March 17, Captain D. Nicholson, "Flying Boat Construction."

EMERGENCY GOVERNOR AND GEAR FOR MARINE TURBINE.

WE illustrate on this and the opposite pages an emergency governor for marine turbine which is being introduced by Messrs. Aspinall's Patent Governor Company, of Liverpool, whose governor for reciprocating marine engines has been extensively used in the past. In the case of marine turbines, although a runaway resulting from the loss of a propeller, breakage of a shaft or other cause, would have disastrous consequences and must be guarded against, these dangers are somewhat remote. The ever-present danger is a breakdown in the oil supply, a cessation of which would wreck the whole plant were the steam not shut off practically instantaneously.

The new governor has been designed to work in combination with the Cockburn-MacNicoll Bulkhead emergency valve, which is universally employed in the Navy, and has also been widely adopted in the Mercantile Marine. The connecting medium between the governor on the turbine shaft and these emergency valves is the lubricating oil. The general arrangement of the installation for a twin-screw vessel is as indicated in Figs. 1 and 2. The oil supply for the bearings as shown in this case is taken from a gravity tank, fixed at a level some 20 ft. or more above the emergency valves, but may equally well be taken direct from the pumps. These emergency valves are controlled by an oil operated relay, and cannot, in normal conditions, be opened unless the oil-piping is under pressure.

Details of these valves are given in Figs. 3 and 4. All steam entering the turbines must pass through these valves. The valve-spindle has, it will be seen, a piston mounted on it, working in a cylinder, fitted below the valve chest cover. The area of this piston is greater than that of the main valve, and steam can be admitted to the left of this piston through the control valve shown. Under these conditions the steam valve is held on to its seat and no steam can reach the turbines. The control valve is operated by an oil relay, the supply being taken from the lubricating mains. When the control valve is open steam passes freely to the left-hand side of the piston, and as the diameter of the latter is greater than that of the main valve the latter is quickly closed should it be open, and kept closed should it be shut. In starting up, oil is admitted to the control valve relay, and shuts off the steam supply to the left of the piston. This makes it possible to open the main valve. This is effected by running back the regulating screw shown. This motion is followed up by the main valve, which ultimately seats itself on a facing formed for the purpose on the head of the cylinder in which the piston moves. Hence, when the steam-valve is fully open, no leakage can occur into this cylinder. This arrangement prevents the possibility of any limeing or binding which might retard the action of the valve when closing. Should the control valve be now opened, either by the governor, or by hand, the high-pressure steam enters to the left of the piston and forces down the main valve on to its seat, where it can be locked by the regulating screw and hand-wheel. From the foregoing it will be seen that the emergency valve cannot be opened until there is a sufficient pressure in the lubricating mains to keep the control valve shut. Provision is, however, made for closing this valve, when necessary, even when the oil piping is not under pressure.

A governor is provided on each turbine spindle. The governors are connected to the oil supply system by a ¾-in. bore pipe, from which a branch is also taken to the underside of the oil cylinder at the emergency steam valve. This system is supplied with oil under pressure from the lubricating discharge pipes through a connection of ½-in. bore. Should the revolutions of any turbine exceed a predetermined rate its governor instantaneously acts and allows the oil from the governor-pipe system to drain to the oil return, and as this system is only supplied through the ½-in. bore pipe, the oil pressure is immediately reduced, the control valve opens (the piston operating it being no longer supported) and the main emergency valve closes and will not (with the arrangement usually adopted) open again until the governor is reset. If, however, the governor is a speed and emergency cut-out governor, it will cut out and cut in again if the maximum speed attained does not exceed 15 per cent., but above this limit it cuts out and has to be reset. Should a stoppage of the lubricating pump remain unobserved until the gravity tank is emptied and the oil falls in the pipe from the gravity tank, the emergency steam valve will remain open only until the head of oil above the operating cylinder falls to about 5 ft. Should the level fall below this point the pressure is insufficient to support the oil piston, the control-valve accordingly opens and the emergency steam valve is closed. When pumping direct to the bearings without the intervention of gravity tanks the governor cuts out when the pressure falls to that corresponding to a head of about 5 feet.

For operating the emergency valve from the starting platform the hand-control valve shown in Fig. 5 is used. This valve is normally kept closed by a spring, but by pushing over the hand lever the oil supply to the operating cylinder is short-circuited to the oil return system and the emergency valve closes accordingly.

The governor is of a simple and positive type. The arrangement shown in Figs. 6 and 7 is that adopted for turbines of the Brown-Curtis type, where it is not necessary to make provision for measuring clearances with the turbine running. A slightly different arrangement is adopted when the governor is to be fitted to a Parsons turbine.

The governor consists of a head which is bolted to one end of the turbine spindle. In this head are arranged two sliding bushes which are pressed together by springs and form a valve, which, by means of the pipe shown on the right of Fig. 7 is connected with the oil

Fig. 1.

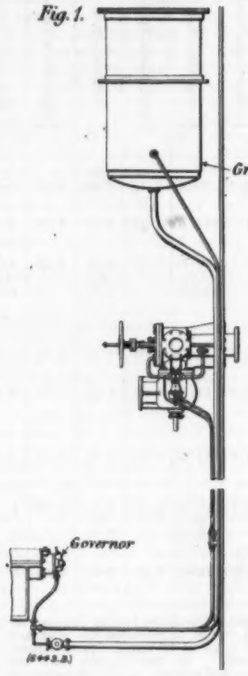


Fig. 2.

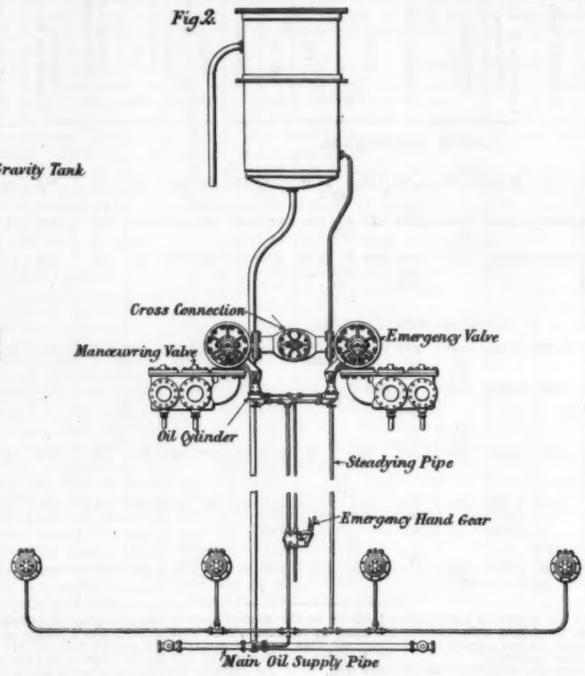


Fig. 3

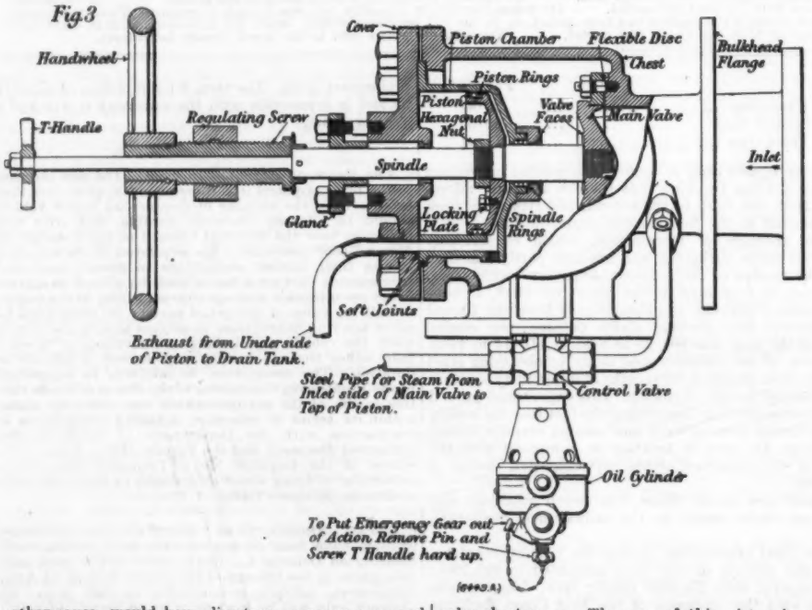
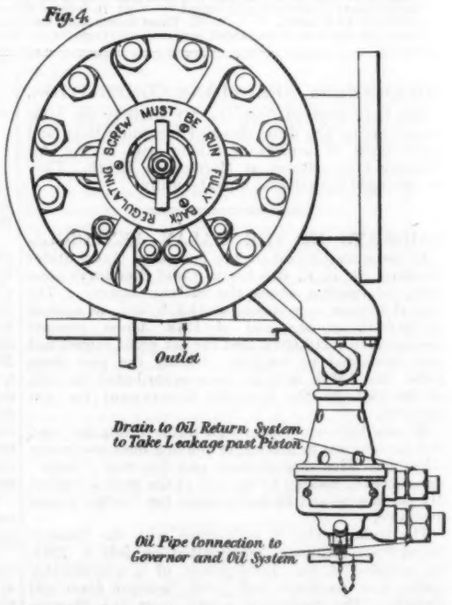


Fig. 4.


MUST BE RUN FULLY BACK REGULATING SCREW
Outlet
Drain to Oil Return System to Take Leakage past Piston
Oil Pipe Connection to Governor and Oil System

supply system. So long as the valve remains closed, the pressure in the oil piping is maintained, but should the two components separate under the action of the centrifugal forces developed when the turbine begins to race, the pressure in the oil pipe is relieved, with the result that the emergency valve shuts off the steam supply, as has been already explained. The two pawls shown in Fig. 7, being also acted on by the centrifugal forces, turn up and catch under the bushes when these separate, and hold the valve open until it is reset by the lever shown. This lever, if pressed to the right, moves forward a sleeve over the tails of the pawls, thus releasing the two components of the valve. In some cases the governor is required to act as a speed regulator as well as an emergency governor. In that case, one of the pawls is removed and the spring on the corresponding component of the valve is adjusted so that motion takes place if the speed exceeds the normal by say, 10 per cent., whilst that controlling the other component is adjusted so that this component moves only when the speed is, say, 20 per cent. above normal. If this speed be attained, the governor acts as an emergency governor since the pawl prevents the return of the bush until the apparatus is reset by hand.

A special feature is the self-locking of the adjusting screws by which the compression of the governor springs is regulated. The adjusting screw flange has six holes, whilst the adjusting key has six protruding pins. On applying the key, as indicated in Fig. 8, the protruding pins depress the locking pins and allow the adjusting screw to be moved, in one or other direction, according as it is desired, to increase or decrease the cutting out speed. Before removing the adjusting key, two of the holes in the adjusting screw are brought over the locking pins, when on releasing the key, the locking pins are pushed by their springs into the holes in the adjusting screw flange and lock it securely. The device may be termed fool-proof, because if the adjusting screw is not moved into a position such that the holes coincide with the locking-pins, and if in this position the adjusting screw does move from any cause such as vibration, it can only move until the holes coincide with the locking-pins, when the latter will automatically be pushed into the holes. The screw shown at the end of the governor head is intended to take the gear used in axially-adjusting the turbine rotor.

The foregoing description while referring particularly to a twin screw vessel is equally applicable to a single screw which calls only for one emergency valve and two governors. The gear has already been fitted in quite a large number of vessels with satisfactory results.

Fig. 5.

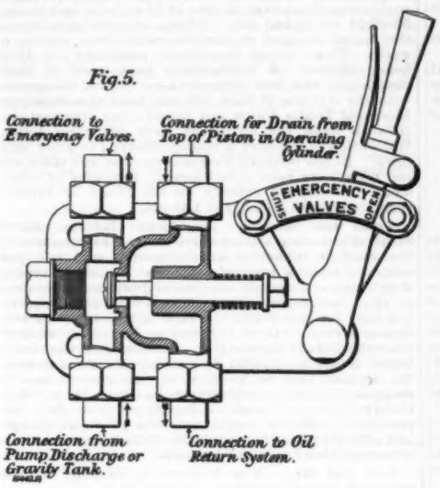

Connection to Emergency Valves.
Connection for Drain from Top of Piston in Operating Cylinder.
EMERGENCY VALVES
Connection from Pump Discharge or Gravity Tank.
Connection to Oil Return System.

Fig. 6.

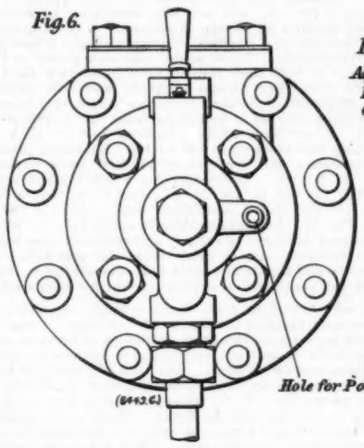


Fig. 7.

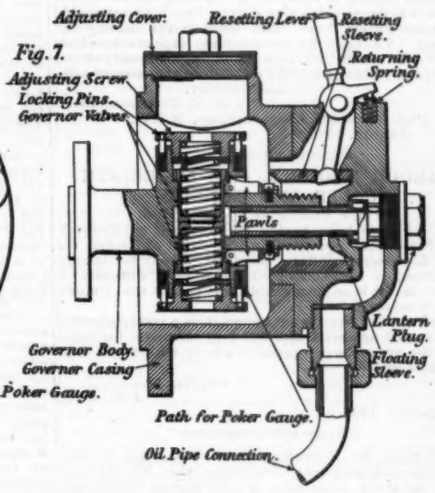
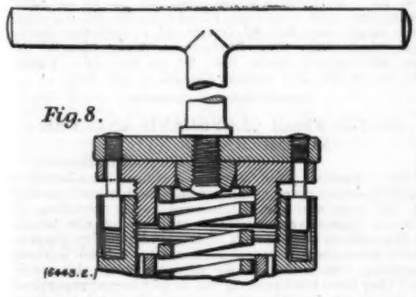


Fig. 8.



"THE ANALYSIS OF YIELD TESTS MADE ON A PERCOLATION WELL"—ERRATA.—The author of the article on the above subject, published on page 272–273 in our issue of August 27, asks us to make the following corrections: Page 272, line 10 of the article, "stiming" should be "steining." Statement II, second column under time 10 minutes, reduction of water level in feet, should be "1·42" not "1·62." Page 273, Statement I as arranged, "h" in column 3, should be "4·45" not "4·65." Third line below, the statement "$w \frac{1}{12}$" should be "or $\frac{1}{12}$ hours." Fifth line below statement "$w h$" should be "which." Second column of page 273, second line,

$$d h - \left(\frac{p - K h}{A}\right) d t$$

should be

$$d h = \left(\frac{p - K h}{A}\right) d t$$

Eighth line from top

$$h = \frac{p}{k}\left(1 - e^{-\frac{K}{A} t}\right)$$

should be

$$h = \frac{p}{K}\left(1 - e^{-\frac{K}{A} t}\right)$$

Line 9 from bottom "$\frac{K}{A}$ w the specific yield," should read "$\frac{K}{A}$ or the specific yield," and similarly "w" should in all other places be converted into "or."

TEST OF 1,500-KILOWATT LJUNGSTRÖM STEAM TURBINE.

We give below a report by Capt. H. Riall Sankey R.E. (Ret.), on a test made by him of a 1,500-k.w. Ljungström steam turbine at the works of Messrs. Marshall, Sons and Co., Limited, Gainsborough. The turbine was constructed by the Brush Electrical Engineering Company, Limited, of the Falcon Works, Loughborough, and had been in regular service for 15 months at the date of the test. No overhaul of the turbine or any other special preparation was made for the trials. The result as corrected to the guarantee figures of stop valve pressure, 190 lb. per square inch gauge; stop valve temperature, 634° F., and vacuum at turbine exhaust = 28¾ in., was 11·95 to 12·00 lb. per k.w. hour, as measured at the switchboard. This result was slightly below the original guarantee, and was obtained as stated, without any preliminary tuning up of the plant. The result indicates that there can have been no serious wear of the blading during its period of service. Capt. Sankey's report is as follows:—

Economy Test of a 1,500-K.w. Brush Ljungström Turbine Generator working at the Lea-road Power Station of Messrs. Marshall, Sons and Co., Limited, Gainsborough, made on March 18, 1920, at the request of the Brush Electrical Engineering Company, Limited, under the Direction of Capt. H. Riall Sankey, C.B., R.E., M. Inst. C.E., in the presence of Representatives of Messrs. The Brush Electrical Engineering Company, Messrs. Marshall, Sons, and Co., Limited, Messrs. Babcock and Wilcox.

The object of the test was to obtain evidence regarding the performance of the plant in the way of steam consumption as instructed in the letters of the Brush Electrical Engineering Company, of May 30, 1913 and November 20, 1919. The plant consists of two 1,500-k.w. Brush Ljungström turbo-generators, each exhausting into its own condenser connected to a three-throw Edwards air pump. The condensing water was obtained from the River Trent and the steam was supplied by a battery of Babcock and Wilcox boilers fitted with superheaters.

The steam conditions specified in the contract with Messrs. Marshall were as follows:—Steam pressure at stop valve, 190 lb. per square-inch gauge; vacuum on turbine exhaust, 28¾ in. (bar., 30 in.); total steam temperature, 634° F. There was an ample supply of steam, but the pressure was 17 lb. per square inch above that of the specification and the superheat at the stop valve was on an average 65° F. lower than the specification. The drop of superheat from the boilers to the turbine stop valve was 30° F. No measurement of coal consumption nor of the water fed into the boilers was made. Only one of the sets was tested, and it was agreed that the result of this test should be taken as applicable to the second set. On the day of the test the set had been running on the ordinary works load and about a quarter of an hour before the intended start, *i.e.*, 10 a.m., the load was increased to the test load by means of a water resistance. Readings were taken every five minutes, starting at 10 a.m., by observers supplied by the Brush Company, and checked at varying intervals by my assistant, Lieut.-Col. C. E. P. Sankey, D.S.O., R.E. (Retd.) and myself, and were continued until 11.55 a.m., when the load began to drop by reason of the shutting down of the works for dinner.

The first reading and the last two readings were disregarded in taking the averages. The load throughout was not quite constant, varying frequently and irregularly about 1¼ per cent. from the mean.

During the dinner-hour a no-load test was taken, but owing to the small amount of condensate the air pump discharge was irregular and the measurement of the water rate can only be regarded as of moderate accuracy. The average of the readings gives a rate of 1,340 lb. per hour, which is only 0·075 of the full load water rate, which is very low, but perhaps not unduly so for this type of turbine.

The works load came on at about 1·20 (13·20), and readings began again at 13.45, and were taken every five minutes under the same conditions as before. This second-full load test continued until 16.25. The variation in load was 1 per cent. from the mean, the variations, as in the morning, being frequent and irregular, and there were occasionally considerable increases amounting to 4 per cent., but only lasting a few minutes.

The measuring instruments used in the test were as follows:—

(*a*) *Electrical measurements.*

(i) Volts.

Portable precision A.C. voltmeter made by the Weston Electrical Instrument Company. No. 962. Calibration by N.P.L.

(ii) Amperes.

Portable A.C. ammeter, made by Ferranti, Limited. No. 85,603. Calibration by N.P.L.

(iii) Kilowatts.

(*a*) Three-phase watt-hour meter, made by the British Westinghouse Electric and Manufacturing Company. No. 678,690. Calibration by N.P.L.

(*b*) Portable precision watt-meter, made by the Weston Electrical Instrument Company. No. 722. Calibration by N.P.L., which notes that the instrument as received was not satisfactory.

(*c*) Station watt-meter. No calibration.

The figures obtained from (*a*), (*b*) and (*c*) were

TABLE I.—*Average of readings corrected in accordance with N.P.L. calibrations.*

	1st Test.		2nd Test.	
	Average of Readings.	Corrected N.P.L. calibrations.	Average of Readings.	Corrected N.P.L. calibrations.
R.P.M.	3,000	—	3,000	—
Voltage	51·19 ×127	6,478	51·19 ×127	6,478
Line amperes	142·76	135·12	144·57	136·88
(1) Indicated k.w. ..	1,509	—	1,515	—
(2) Indicated k.w. ..	279·65 ×5·5	1,488	283·4 ×5·5	1,457
K.w. by k.w.-hour meter	1453·8	1,474	1,483	1,504
Lea recorder integrator lb. per hour	18·180	—	18·675	—
Lea recorder drum ..	18·019	—	18·227	—
Steam pressure before stop valve gauge lb. per square inch	208	—	206	—
Turbine vacuum by Hg. column .. ..inches	28·74	—	28·63	—
Temperature of steam before stop valve deg. F.	585	583	570·7	568·7
Temperature in exhaust deg. F.	87·8	—	88·0	—
Temperature air pump suction .. deg. F.	57·3	—	58·8	—
Temperature of condenser steam deg. F.	69·3	—	69·6	—
Condenser back pressure, lb. per square inch .. .. Abs.	0·68	—	0·64	—
Temperature of circulating water in deg.F.	44·1	—	45·4	—
Temperature of circulating water *out* deg. F.	56·0	—	56·3	—

TABLE II.—*Principal results.*

	Trial No. 1.	Trial No. 2.
1. Time—Beginning	10.05	13·45
2. Time—End	11·45	16·25
3. Duration of trial..	1 hr. 40 m.	2 hr. 40 m.
4. R.P.M.	3,000	3,000
5. Steam pressure at stop-valve gauge .. lbs per square inch	208	206
6. Steam temperature at stop valve .. .. deg. F.	583	569
7. Condenser back pressure, lbs. per square inch .. Abs.	0·68	0·64
8. K.V.A.	1,516	1,536
9. K.W.	1,469	1,492
10. Weight of steam per k.w. hour*	12·42	12·47
11. Weight of steam per k.w. hour, corresponding to contract steam conditions†	12·00	11·95
12. Weight of steam per k.w. hour, corresponding to contract steam conditions‡	12·00	11·93
13. "Equivalent Feed" lbs. per k.w. hour§	14·07	14·03
14. Heat supplied per min. per k.w.‖	258·0	257·0
15. Overall efficiency ratio (taken on k.w. output)	68·0 per cent.	68·4 per cent.
16. Turbine shaft efficiency ratio, assuming 94 per cent. generator efficiency¶	72·4	72·8

* Including shaft gland steam, which was 0·85 per cent. of turbine steam.

† Deduced from graphs given in "Steam Turbine," by William J. Goudie, B.Sc., &c., 1917, page 360.

‡ Deduced by ratio of heat-falls (Marks and Davis Steam Tables).

§ In accordance with the standard forms for tabulating the results of steam engine and boiler trials of the Institution of Civil Engineers, line 131.

‖ In accordance with the standard forms for tabulating the results of steam engine and boiler trials of the Institution of Civil Engineers, line 125.

¶ This efficiency is assumed because it was that of the 1,000-kw. Ljungström generators, tested by me in Stockholm in May, 1912.

given weights of 4, 2 and 1 respectively, to obtain the figure used in calculating the results of the test.

(*b*) *Steam measurements.*

(i) Pressure.

B.E.E. Co. Standard Duplex pressure gauges. No calibration.

(ii) Vacuum.

Turbine casing vacuum by B.E.E. Company. Mercury column. Other readings by station instruments.

(iii) Temperature.

Turbine temperatures by calibrated B.E.E. Company thermometers. Calibration by N.P.L. of thermometers Nos. 192,436 N.P. 20 and 501. Other readings by station instruments.

(*c*) *Water measurements.*

(i) Condenser water.

(*a*) Lea recorder drum.

(*b*) Lea recorder integrator.

Neither of these methods was calibrated during the test, and each was given the same weight in calculating the results of the test. A calibration previously made by Mr. Dutton was accepted and examined.

(ii) Gland steam.

Measured in a tank, the capacity of which was known. A small excess measured in buckets and weighed.

Results of the trial.—The complete results of the readings, taken by the Brush Company's observers are given in the blue print attached.* These have been plotted and compared with the check readings taken by Colonel Sankey and myself, and are accepted. The average of these readings has been obtained arithmetically and checked graphically, and is given in Table I, together with the corrections in accordance with the N.P.L. calibrations.

The deductions from these results are given in Table II, showing the actual steam consumption per k.w. hour, and also when reduced to the specification steam conditions. The efficiency ratio of the British thermal unit per k.w. is also given.

Throughout the tests the set ran remarkably well.

(Signed) H. RIALL SANKEY.

THE CARBO-TEREDO TIMBER PROCESS.

TO THE EDITOR OF ENGINEERING.

SIR,—The degree of prominence given to this process in the first report of the committee inquiring into the deterioration of structures in sea water may induce engineers to embark upon further tests. It is therefore important that it should be understood that heaters should be used for the primary burning, as well as for the secondary treatment during driving or fixing in position. I am induced to stress this point because the writer of one of the papers appended to the report who has already done a great deal for my process, has thus expressed himself: "The principal advantage that I can see in this process is that if the timbers are previously charred *by open fire*, any abrasions that may occur through handling can be made good by means of a blow lamp or, in the case of piles, injuries caused in driving can be re-charred. In other timbers this can be effected after they have been placed in position."

It has been proved that charring in an open fire causes the impregnation to volatilise too quickly for the formation of a superior protective crust. It is also impossible to re-impregnate knots and other faults during the burning. The open fire also produces large cracks which do not close readily, whereas the heater chars only shows small cracks which generally close during the second tide.

Yours faithfully,

JAS. E. CUNNINGHAM.

54, Post Office Chambers, Sydney, N.S.W.,
July 10, 1920.

LABOUR TROUBLE: ITS IMMEDIATE CAUSE AND REMEDY.

TO THE EDITOR OF ENGINEERING.

SIR,—I have been hoping to see some criticism of "An Employers" proposal in your issue of August 13, for it does seem to offer a practical remedy for labour difficulties, if it be adopted. The only difficulty I foresee, and it is an insuperable one, is that the Unions will not accept it.

The fact that they do not accept it, is a good debating point scored against them, but it is no more, for logic and right can make no appeal to a body with might but without a soul.

I am, Sir, &c.,

J. C. R.

August 20, 1920.

THE LATE MR. EDWARD KING.—We regret to see, from the *Schweizerische Bauzeitung*, that Mr. Edward King, for some years chief of the engine, boiler and shipbuilding departments of Messrs. Escher Wyss and Companie, of Zürich, and later chief partner in the firm of King and Co., of Wolleshofen, near Zürich, died suddenly on August 21. Mr. King was of British descent, born in Zürich in 1861; his father was at the Neumühle foundry in Zürich, which the son later transformed. Edward King was apprenticed to Messrs. Escher Wyss, worked from 1879 to 1884 in England, and then returned to his original firm. The shipbuilding departments of some Swiss works are by no means unimportant, we may mention. In 1891 King started on his own account to build boilers, locomotives, engines, steam rollers, &c. The war hit his business hard, but he was able to recover his position.

THE MOTOR SHIP "THEODORE ROOSEVELT."—In our last volume we gave illustrated descriptions of the motor ships Asia and Afrika, built by Messrs. Burmeister and Wain, Copenhagen. The same firm have recently completed the motor-ship Theodore Roosevelt, a vessel which is built to Lloyd's class 100 A.1, and is also classed by the Norwegian Veritas. She has the following dimensions and characteristic features: Length overall, 444 ft. 4 in.; length between perpendiculars, 425 ft. 5½ in.; breadth on frame, 55 ft.; draught loaded, 29 ft. 1 in.; displacement, 15,065 tons; gross tonnage, about 7,116 registered tons; radius of action, about 30,000 miles. She is propelled by two main Diesel engines developing a total of 3,100 i.h.p., and carries three auxiliary Diesel engines each of 60-kw. capacity. Her speed at full load is about 11 knots. The main machinery consists of two six-cylinder, single-acting four-cycle Diesel engines, of the Burmeister and Wain crosshead type, enclosed and provided with forced lubrication. The engines are fitted each with a three-stage air pump for the injection air and one fuel pump for each cylinder, all other pumps being separately driven. The engines develop normally and continuously during daily working at sea the total of 3,100 i.h.p. at 125 r.p.m. The oil fuel consumption is about 10¼ tons per 24 hours.

* We do not reproduce this.—ED.E.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Engineering Lock-out.—Between 500 and 600 members of the Electrical Trades Union employed by federated engineering firms over an area of 15 miles in and around Sheffield are locked out. Fifteen hundred members of this union engaged at non-federated firms remain at work. There is no immediate possibility of their being affected. A considerable proportion of those electricians who were under lock-out notice, disagreeing with the attitude of their officials, have abandoned the Electrical Trades Union and joined other organisations. In such cases the employers have taken no action. Dislocation of industry is mainly confined to a few large firms. In one instance Siemens furnaces, and sheet and rail mills have been closed down. Prospects of settlement now depend entirely on the Court of Inquiry suggested by the Ministry of Labour.

Trade with Germany.—Mr. Arthur Balfour, one of Sheffield's leading steel makers and an ex-president of the Sheffield Chamber of Commerce, who has just returned from a tour of industrial Germany, reports that there is a certain amount of business to be done in steel and engineering products with that country, but only for spot cash. In view of the unsettled conditions prevailing there, it is unwise, he says, to attempt to establish credit connections. Production in Germany's heavy trades is crippled by scarcity of raw materials. Mr. Balfour fails to see how, at the current rate of progress, German manufacturers can keep their "fictitiously built-up" works occupied or how they can produce a sufficient output to cover overhead charges and sell at a price that would hit British manufacturers in competition for export business.

Iron and Steel.—New business is retarded by the unsettled labour position, coupled with the scarcity of raw materials. Engineering firms possessing their own furnaces are prospecting in other parts of the country for ore, and are also arranging to augment home supplies by foreign shipments. A development is the decision of a Sheffield concern to build a new dock at Workington. Construction will occupy two or three years. It will then furnish accommodation for large boats conveying foreign supplies, and will facilitate the shipment of finished materials direct to Liverpool. The scrap market is benefiting from the dearth of pig-iron. Prices have again advanced 10*s.* to 1*l.* a ton, making best steel scrap 13*l.* to 14*l.* Minimum prices of Lincolnshire and Derbyshire pig-iron have advanced 12*s.* 6*d.* per ton. Derbyshire No. 3 foundry now stands at 14*l.* 17*s.* 6*d.* to 15*l.* 2*s.* 6*d.*, Derbyshire No. 4 forge 13*l.* to 13*l.* 5*s.*, Lincolnshire basic 14*l.* 12*s.* 6*d.* to 14*l.* 17*s.* 6*d.*, and Lincolnshire foundry 14*l.* 15*s.* to 15*l.* Increased deliveries of railway and tramway steel would, it is believed, attract more orders for renewals. The crucible and high-speed steel branches are quiet, but a brisk call continues on export account for mild steel.

South Yorkshire Coal Trade.—With all classes of consumers pressing for increased deliveries to augment emergency stocks, the gross output of collieries is going away daily on contract commitments leaving no surplus for open market disposal. The rush of orders for house coal is far greater than either collieries or depots can keep pace with. A big tonnage of secondary grades is going to London and the South. Works have acquired fair stocks of gas fuels, but have not yet reached what is regarded as the safety line. There is a strong demand for furnace coke. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*: rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is very quiet, traders in this, as in other branches of the iron and steel industries being unwilling to commit themselves until the outcome of the action of the colliers is apparent. Cleveland foundry pig-iron continues scarce. Several furnaces have been working anything but satisfactorily of late, with the result that they have been turning out unduly large proportions of the lower qualities of pig-iron. Demand for forge iron is good. This quality is being more extensively taken up for despatch to Scotland to mix with superior iron. There are still no export quotations for Cleveland pig-iron. To home customers, No. 1 is 237*s.* 6*d.*, and No. 3, as well as the common kinds, is 225*s.*

Hematite Iron.—In the hematite department makers have little iron to dispose of, most of them having sold their output over the next few months, but second hands continue able to offer fairly large parcels. Home customers are understood to be pretty well bought, but foreign transactions show some expansion, sales being reported to European Allies and to neutrals. For home use, Nos. 1, 2 and 3 East Coast brands are 260*s.*, and No. 1 is 262*s.* 6*d.*; whilst for shipment to France, Belgium and Italy, mixed Nos. are 265*s.*, and No. 1 is 267*s.* 6*d.* Some sales of mixed Nos. to neutrals are understood to have occurred at 270*s.*

Production of Pig-Iron.—Output of Cleveland pig-iron is larger, a couple of furnaces which had to be temporarily shut down, having been restarted on that commodity, making the number in blast on Cleveland iron 30; whilst

25 are running on hematite, and 16 furnaces are producing special kinds of iron, the total number in operation in this district thus being 71.

Foreign Ore.—Circumstances point to more extensive trade in foreign ore. Buyers and sellers' ideas of values are not so wide apart as they have been, but even yet they do not agree over readily as to terms. They are quite prepared to discuss business, however, and the few sales that have been put through recently appear to have been at round about equal to 47*s.* 6*d.* ex-ship Tees for rubio, of 50 per cent. quality. The freight Bilbao-Middlesbrough runs from 17*s.* 3*d.* to 17*s.* 6*d.*

Coke.—Supply of coke is barely sufficient to meet really essential home requirements, and there is none to spare for export. Average blast-furnace kind remains at 62*s.* 9*d.* at the ovens; and quality low in phosphorus still stands at 56*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—There is little or nothing passing in finished iron and steel. No disposition to do forward business is shown, but firms are kept busy on current contracts. Foreign customers, however, who only a short while ago were keen to place orders, are in many cases seeking to cancel contracts, and indeed cancellations have already occurred. Values of some descriptions show a rather downward tendency, and sheets have been actually lowered. On the other hand steel angles have advanced 20*s.* Common iron bars are 30*l.*; marked bars, 32*l.*; iron ship angles, 30*l.* 15*s.*; channels and flats, 23*l.* 5*s.*; rounds and squares, 25*l.* 10*s.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 30*l.*; steel joists, 23*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy sections of steel rails, 25*l.* 10*s.*; fish plates, 30*l.*; black sheets, 38*l.*; and corrugated, galvanised sheets, 47*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The invitation of Sir Robert Horne to the Miners' Executive to meet him with a view to clearing up misunderstandings in their respective points of view in regard to the coal position is taken as a hopeful sign. Hopes are entertained that the interview will result in the finding of a way out of the present *impasse* and the calling off of the strike threat. Meanwhile preparations are being made for emergencies. On the South Wales coal market new business is rendered practically impossible, as almost the whole of current outputs are required to fulfil contract obligations, and bunker vessels proceeding from the district, either with cargoes or in ballast. Bunker supplies are in fact very scarce, and though owners are able to secure available quantities from collieries at the fixed prices of 80*s.* for large, 75*s.* throughs, and 60*s.* smalls, middlemen with such descriptions for disposal can realise premiums of 5*s.* from owners who prefer to pay up rather than have their vessels delayed. During the past week an order has been issued by the Board of Trade altering the maximum f.o.b. prices applicable to bunkers for vessels employed in the United Kingdom trade to pithead prices equivalent to the prices paid by home industries, which is 23*s.* 2*d.* above the standard pithead prices in the twelve months ending June, 1914. To the pithead prices must be added railway rates, tipping and weighing charges, estimated at about 4*s.* 2*d.* per ton. Though shipowners in the coasting trade will have to pay on the whole more for their bunkers under the new order they will as a matter of fact be securing their supplies cheaper than had the old order remained in force, and the extra railway rates and dock charges been added to the old schedule. The maximum pithead price, plus railway and dock charges, works out at about 3*d.* above the old f.o.b. price, while the increased rail rate and dock charges from September 1 are estimated at 1*s.* to 1*s.* 6*d.* per ton. Foreign exports of coal from South Wales last week totalled 250,857 tons, of which 140,357 tons went to France, 15,591 tons to Italy, 19,190 tons to South America, 9,388 tons to Spain, 21,415 tons to Portugal, 38,156 tons to British coaling depots and 6,760 tons to other countries.

Iron and Steel Trades.—There is a fair inquiry for tin plates, but sellers, in view of the threatened labour outlook and the increased railway charges, are disinclined to do business. For prompt delivery, standard boxes are round 57*s.*, with the quotation round 55*s.*, for end of the year delivery. Galvanised sheets are in poor request, with prices easy at 43*l.* 10*s.* for 24-gauge corrugateds.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The unsettled state of labour throughout the country and the possibility of a coal miners' strike in the near future have had a slight check in the demand for steel material. Nevertheless, the various establishments are all actively employed, and consumers are all eager for deliveries and are desirous of having something on hand in case of a stoppage at the collieries. Buyers are still holding off, and although prices are meantime unchanged, a much easier tendency prevails and they are hopeful that before long they will be able to place their business on more favourable terms than prevail at present. The consumption of plates, &c., at the shipbuilding yards continues on a large scale, but with no new orders being fixed up this outlet will gradually become much smaller, and the future is not too bright; but conditions may alter considerably before present orders are worked off. Structural sections are more easily obtainable this week. The makers of black sheets continue busy, particularly on home account and all plant is running at full speed. Foreign buyers are again in the market, and have forward good inquiries for both black and galvanised sheets for early shipment. As far as can be learned no great quantity has been fixed up yet on account of the fullness of order books, but whatever can be spared is being offered. Corrugated sheets are in request for the Argentine, and some fair lines have been booked.

Malleable Iron Trade.—There has been little change in the malleable iron trade of the West of Scotland since last report, and all mills are going at top speed. The home trade is taking up most of the output, but the demand is not quite so pressing of late and a little more is available for export. Continental competition is not of any great moment as the deliveries have not amounted to a heavy tonnage yet, although larger quantities are being mentioned.

Scotch Pig-Iron Trade.—Active conditions still rule in the Scotch pig-iron trade, and every ton turned out is quickly absorbed, as the local consumers are all anxiously awaiting deliveries. Foundry iron continues scarce, and No. 1 quality is quoted round 14*l.* per ton, free on trucks, at makers' yards, while No. 3 is about 10*s.* per ton less. Hematite is in good demand, and so long as the steelmakers keep busy this state will continue. The current price delivered at the steel works is 14*l.* 5*s.* per ton. The shipping side of the industry shows improvement, and any slackness in the home demand will be counterbalanced by export. Foreign competition is gradually making itself felt and Continental makers are beginning to feel their way into our markets once more. They have worked steadily since the termination of hostilities, and although they have had their own troubles to fight against they may shortly be a force to reckon with.

State of Trade.—The general trade of the country is not as buoyant as it has been during recent months, and in many branches the lack of inquiry is very noticeable. There has undoubtedly been a falling off in orders, and those who come most into contact with the actual consumer state that the latter is now playing the waiting game because of the rooted conviction that prices must fall considerably before long. With lower prices will come lower wages, to the workers, which will require to be accepted or many industries will temporarily cease operations. Labour meantime has not stopped its demand for higher rates, but in view of foreign competition these can scarcely be conceded now if steady employment is to continue. The horizon is darkened at present with the threat of a strike amongst the coal miners, but efforts are being made to prevent such a calamity, although many would welcome a strike in the hope that the great struggle of Capital *versus* Labour, which has threatened industry for so long, would finally be fought out and settled.

THE SIR JOHN CASS TECHNICAL INSTITUTE.—The new session of the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C., will commence on Monday, September 27. The courses of instruction provided are especially directed to the technical training of those engaged in chemical, metallurgical and electrical industries and in trades associated therewith. Full facilities are provided for those wishing to carry out work associated with the industries in which they are engaged or to undertake special investigations and research. The chemistry, metallurgy and physics laboratories are open both in the afternoons and evenings for work of this character. The instruction in experimental science also provides systematic courses in chemistry, physics, and in pure and applied mathematics for the examinations of London University, and in chemistry and metallurgy for the examinations of the Institute of Chemistry. Full details of all the courses are given in the syllabus of the Institute, which can be had on application at the office or by letter to the principal. The principal and heads of the departments will attend at the Institute to interview students during the week from Monday, September 20, to Friday, September 24, from 7 to 9 p.m.

THE ELECTRICITY COMMISSION.—The Electricity (Supply) Act came into effective operation on January 23 last when the powers and duties previously exercised by the Board of Trade were transferred to a body of Electricity Commissioners under the chairmanship of Sir John Snell. As the result of a preliminary survey of the situation the Commissioners have satisfied themselves that the supply of electricity should be improved in several areas, amongst these being the Lower Severn District, the Mid-Lancashire, the South-East Lancashire and the Mersey and West Lancashire Districts; in addition to the West Riding and North Wales districts. With respect to provisional orders pending, the Commissioners propose to deal on their merits with three applications made by the South Wales Electric Power Distribution Company, but have refused an application from the Havant Urban District Council on the ground that it was undesirable to increase the number of small generating stations. The proposal of Manchester for the construction of a station at Barton with a possible ultimate capacity of 150,000 kw., has been sanctioned, as has that of the Corporation of Leicester for a new power station with an ultimate possible capacity of 50,000 kw. An application by the Corporation of Nottingham, and one by the Derbyshire and Nottinghamshire Electric Power Company, have been held up for further inquiry. In dealing with such matters, the policy of the Commissioners is to discourage the extension of a badly-placed station in one district when a supply is possible by extending a better situated station elsewhere.

NOTICE OF MEETING.

THE INSTITUTE OF METALS.—Wednesday, September 15, at 10 a.m., in the Town Hall, Barrow-in-Furness. General Meeting of members. The following papers will be read and discussed: "Notes on Brass Foundry Practice at Messrs. Vickers, Limited, Barrow," by Mr. H. B. Weeks, F.I.C.; "Crystal Growth and Recrystallisation in Metals," by Professor H. C. H. Carpenter, F.R.S., and Constance F. Elam; "The Influence of Gases on High-Grade Brass," by Mr. T. G. Bamford, M.Sc., and Mr. W. E. Ballard; "The Constitution of the Alloys of Aluminium and Magnesium," by Mr. D. Hanson, M.Sc., and Marie L. V. Gayler, B.Sc. From 2 p.m. to 5 p.m. visits to works. Thursday, September 16, at 10 a.m., General Meeting of members. The following papers will be read and discussed: "The Effect of Increasing Proportions of Antimony and of Arsenic respectively upon the Properties of Admiralty Gun-Metal," by Mr. R. T. Rolfe, F.I.C.; "Service Experience with Condensers," by Engineer Lieutenant-Commander G. B. Allen, R.N.; "Some Features in the Behaviour of Beta Brass when Cold-Rolled," by Mr. F. Johnson, M.Sc.; "Note on the Failure of Manganese Bronze," by Mr. J. H. J. Dickenson. The other papers on the list are: "The Allotropy of Zinc," by Kathleen E. Bingham, B.Sc.; "The Constitution and Structure of Certain Tin-Antimony-Copper Alloys," by Mr. O. F. Hudson, D.Sc., and Mr. J. H. Darley.

THE IMPERIAL MOTOR TRANSPORT CONFERENCE.—By the courtesy of the Society of Motor Manufacturers and Traders, the meetings of the conference in process of organisation by the Imperial Motor Transport Council will be held in the Pillar Hall of the Olympia Building, West Kensington. There are to be morning and afternoon sessions on October 18, 19, 20 and 21, for the discussion of various problems and developments connected with Empire fuels, roads and transport. At the time of the conference the main Olympia building will be devoted to the Society's Exhibition of Commercial Motor Vehicles. Delegates at the conference will have the opportunity of supplementing, by the study of practical developments, the information rendered available as a result of the discussions which will take place.

THE SCARAB SYSTEM OF OIL FUEL BURNING ON LOCOMOTIVES.—Since the account given on page 324 *ante*, of the Scarab system of oil fuel as applied to locomotives, we have received from Mr. C. J. Bowen Cooke, C.B.E., locomotive superintendent of the London and North-Western Railway, some figures relating to a run of an engine fitted with this system. The engine was the "Watt," No. 2,585, and the figures are for a run between Euston and Birmingham on September 1. The fuel consumption worked out at 36·12 lb. per mile, or 9·41 lb. per 100 ton-miles, which is below the figure given in our previous notice. The London and North-Western figure includes lighting up oil. The oil used was of a very dark brown colour, of 0·907 specific gravity and flash point of 180 deg. F. Its calorific value was 19,366 British thermal units. Steam was well maintained. The load was 287 tons behind the tender.

H.M. LIGHT CRUISER "RALEIGH."—The Raleigh, built by Messrs. W. Beardmore and Co., recently left their fitting-out basin at Dalmuir prior to her trials which are proceeding this week. With the Raleigh three other light cruisers of the "Improved Birmingham" class were laid down, at Chatham, Portsmouth and Devonport. Owing to the armistice, however, only one of these three had been completed—the Hawkins—and she has proved a fine sea ship. Another of this class was the second Vindictive, originally Cavendish, but afterwards changed in name and purpose and completed as an aircraft carrier. The completion of the Raleigh has been delayed from time to time, owing to the gradual passing of the conditions which called her class into being. These ships have an unusually large fuel capacity. Also, since oil fuel might not be obtainable at distant naval stations and ports, they were arranged to carry some coal, and four small coal-burning boilers were provided giving sufficient steam for cruising speeds. The Raleigh has bunker space for 800 tons of coal and twice the equivalent in oil. Internally the design is very spacious, and both the Raleigh and Hawkins should make excellent flagships to light-cruiser squadrons. The Raleigh is armoured on light-cruiser lines, with a maximum of 3 in. plating amidships. A noteworthy feature is her torpedo-proof bulges, which were applied in all later ships. These are 10 ft. deep in the Raleigh. For further protection she has unpierced bulkheads below the lower deck. It is estimated that the bulges and subdivisions of the ship would keep her afloat even if all three boiler rooms and both engine rooms were flooded. The main armament consists of seven 50-calibre 7·5 in. guns, of a new semi-automatic breech-loading type with high-angle elevation. It is unofficially stated that the projectile is light and the muzzle velocity high, so that the range should be limited only by maximum visibility. She carries four 21-in. torpedo tubes above water and two submerged. The Raleigh is a quadruple-screw vessel, with four Brown-Curtis geared turbines developing about 70,000 shaft horse-power on oil fuel, and a speed of some 31 knots. Her displacement is 9,750 tons, overall length 605 ft., beam (outside bulges) 65 ft., and at water line 58 ft., mean draught 17 ft.

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)

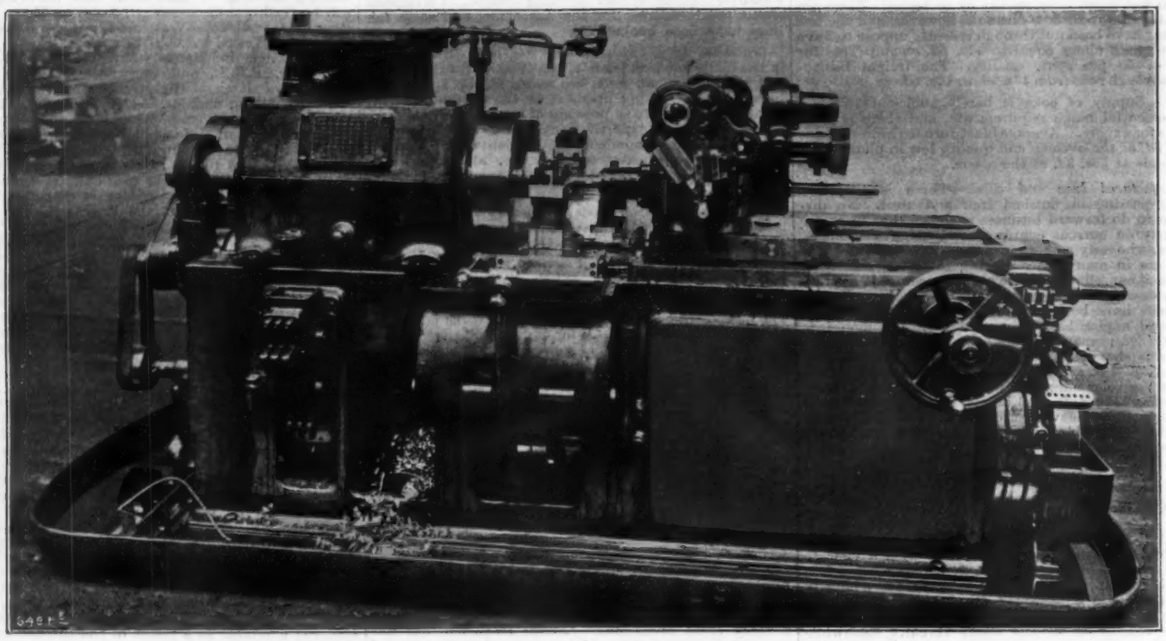


FIG. 101. FRONT VIEW OF AUTOMATIC LATHE; MESSRS. ALFRED HERBERT, LTD.

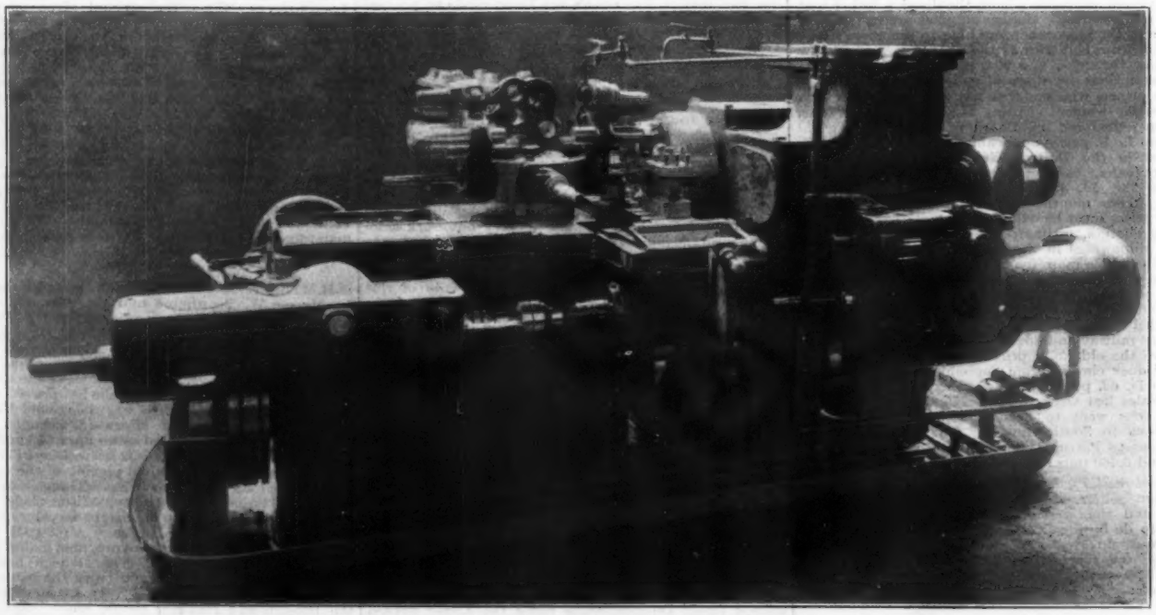


FIG. 102. BACK VIEW OF AUTOMATIC LATHE: MESSRS. ALFRED HERBERT, LTD.

PORT OF LA PALLICE, FRANCE.—According to a decree published in the *Journal Officiel*, the Chamber of Commerce of La Rochelle is authorised to raise a loan of 2,100,000 francs for the purpose of effecting certain improvements at the port of La Pallice. These improvements include the acquisition of eight electric cranes and the construction of electric tracks for the same; the enlargement of the electric sub-station; the lengthening of four sheds and construction of two sheds.

HYDROCHLORIC ACID FROM CHLORINE AND WATER.—In the old Deacon process a mixture of gaseous hydrochloric acid (from the saltcake furnaces of the Leblanc soda process) and air is passed over hot bricks, impregnated in the cold with copper chloride; the hydrogen of the HCl then combines with the oxygen of the air to form water, and chlorine is liberated. In this chlorine production the copper chloride (which may be replaced by other chlorides) acts as catalyst. So much chlorine and hydrogen are now liberated by electrolytic decomposition of salt in the manufacture of caustic soda that hydrochloric acid is made from these gases, and it has also been suggested to reverse the Deacon process, that is, to prepare HCl from chlorine and water. It is well known that chlorine and water react with one another, especially when exposed to light, and that for this reason the chlorine water, kept in laboratories, slowly changes into hydrochloric acid. There are two reversible reactions: $Cl_2 + H_2O = HCl + HClO$, and $HClO = HCl + O$, that is, hydrochlorous acid is first formed which soon splits into $HCl + O$. The first of the two reactions is very slow, however, and the problem is to find a suitable catalyst for this otherwise very promising reversed Deacon process which might yield both chlorine and oxygen by an inexpensive method. H. D. Gibbs, of the Washington Bureau of Chemistry (*Journal of Industrial and Engineering Chemistry*, June last, pages 538 to 541) has tried charcoal as catalyst. He found that he could get all the HCl, but not the oxygen, the reaction being $2Cl_2 + 2H_2O + C = 4HCl + CO_2$. Thus in the presence of water the carbon catalyst is itself converted into CO_2 which has very little value. Yet by blowing steam and some air through a layer of charcoal at about 150 deg. C. he obtained a good acid, but he also discovered that such processes had been patented more than twenty years ago by Lorenz, Peter and others, who recommended different temperatures. With an excess of steam, however, at 100 deg. C., Gibbs realised a good yield of HCl without attacking his charcoal, and further study of the reversible reactions and their equilibria may lead to satisfactory results.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 5 0
For Canada—	
Thin paper copies	£2 18 6
Thick ,, ,,	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With Eight One-Page Plates of the MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 347.

ENGINEERING.

FRIDAY, SEPTEMBER 10, 1920.

THE MACHINE TOOL.

THE Amalgamated Engineering Union differentiates between machine tools which it is allowable for an unskilled man to use and those which can only be properly worked by a skilled man. The line of demarkation is known to all shop engineers, but it is doubtful if it can be supported by any logical process. All machine tools are at bottom methods of replacing skilled handicraftmanship. This is probably the way the general public regards the matter. Sir Alfred Herbert, at the dinner which inaugurated the present Olympia exhibition, found it necessary to point out, for the benefit of the lay press, that the members of the Machine Tool Trades' Association did not make hand-hammers. It is doubtful if this disclaimer was necessary. As a result of war experience the general public has a fair idea what machine tools are and does not confuse them with hand-hammers. In its opinion a machine tool is a machine which enables any servant-girl to make shells or locomotive engines. This idea is naturally exaggerated, but in its crude way is not unsound.

Some profit may possibly lie in considering the matter from this point of view. Any machine tool is obviously designed to carry out a job mechanically instead of doing it by hand. The development of the machine tool now enables it to carry out many processes which could not be done by hand at all, but the main idea of substituting machine processes for hand processes still runs through them all. Many small capstans and automatic screw-machines are to be seen at Olympia, but the work they do *could* be turned out by hand, and as an example we believe we are correct in saying that the small pivot screw of the ordinary pair of scissors is still, to a large extent, made by hand in Sheffield. An intelligent first-year apprentice could, of course, set up a capstan and turn out scissors screws of a quality and at a rate which he could not approach if he served a twenty-years' apprenticeship making them by hand. He would want skill in setting-up, but it is a much more easily gained skill than the earlier type. The machine has made the job less of a skilled man's job. The same thing runs through the whole range of machine tools up to the most complicated gear-cutter, and to this extent the public idea is correct, that a machine tool is a tool which enables a servant-girl to make engines.

In opposition to this idea it may be pointed out that very many of the machine tools at Olympia are obviously skilled-man's tools which an unskilled man could do nothing with. This obvious fact is not to be disputed, and we are almost prepared to say that an unskilled man cannot unaided do anything with any machine tool except smash it. We are not prepared to admit two contrary propositions, however. Machine tools in general tend to eliminate hand skill, but all, or nearly all, demand skill in setting-up. This is work for a tradesman and not for a labourer. Many machine tools, again, are engaged on such a variety of work on the particular class of job they do requiring so many tool changes, that setting-up becomes the principal part of the job. In such circumstances there is clearly no object in introducing the unskilled or semi-skilled operator at all. The main thing which should be recognised, however, particularly by organised skilled labour is that the purpose of the machine tool is to increase the output per workman and to improve the quality by decreasing hand work. Put in this form, it might appear that the machine tool is out to eliminate the skilled man, but experience has shown that proper utilisation of the possibilities of machine tools with non-technical operators has created new and more work for the tradesman both in the manufacture and the supervision of the plant.

It is to be hoped that many of our own skilled tradesmen will visit the Olympia exhibition and that some of them, looking at the machines which are to be seen there, will reflect on the present trade union attitude towards various types. During the course of last year we were in the shops of a large steam turbine manufacturing company, and saw a battery of milling machines forming turbine blades. It was explained to us that up to a few weeks previously the work had been carried out by girls as a war measure, but that with the return to more normal conditions the union had insisted that the machines were skilled men's machines, and skilled men had had to be put on them. The blades, it should be explained, were formed from a copy and the job was as automatic as the operation of a Potter and Johnston. This case illustrates an inconsistency in trade union practice, since in the same works girls were operating machines punching armature stampings.

The basis of the skilled man's position is that he is going to retain any type of operation and any type of machine which has not already passed into the hands of unskilled labour. This is a position that one can understand, but it is really very unsound even from the skilled man's point of view. All machine operations were once skilled men's work, but in some way or other some have passed into the hands of girls and unskilled men. If this movement is economically necessary, no skilled union can ultimately prevent it, and one result of opposition will be that more and more trades will follow the sewing-machine and bicycle industries, and practically pass out of the control of the skilled unions altogether. The remedy is in the hands of the skilled man. Let him frankly admit that the carrying-out of a purely mechanical routine operation is no work for a tradesman. This concession will do him no harm. His position gives him magnificent bargaining power, and in return for turning-over routine machine work to unskilled labour, he may demand, and will get, conditions in connection with relative wages and supervision that will improve his status and put him in a better position than he now is.

The importance of this matter from the point of view of the output of the country's workshops we need not insist on, but in the face of rising costs and a weakening market one very closely allied matter calls for mention. The visitor to the Olympia show will find that the majority of the single-purpose machines on view are of American manufacture. In pre-war days few such machines were made in this country, but nearly two years has now elapsed since the Armistice, and if all our talk of mass production was anything more than the echo of a vain desire, one would expect that its effect would to some extent have been evident in the products of our machine-tool makers. It is to be feared that we have taken no plunge into mass production. We may have had the desire, but the faith has burned low. The ways of labour, international unrest, and other matters have, no doubt, had effect, but that does not alter the fact that, judging by the indications at Olympia, we have as yet done little more than think of the possibilities in this direction.

This state of affairs suggests that not only the skilled workman, but also the manufacturer and his manager may very profitably pay more than one visit to the show; not, however, necessarily with the idea of purchasing American single-purpose

machinery. Much of this machinery is admirable of its type, and its makers have done and will no doubt continue to do excellent business in this country. The single-purpose machine, however, is, after all, but the adaptation and special arrangement of a more general type of tool to a particular purpose, and we should like to think that our manufacturers will avail themselves of the exceptional opportunity they now have to see the best that our machine-tool makers are doing, and to consider to what extent they may not adopt or adapt some of their products to a more intensive output. We are afraid that the present position of mass production in this country is such that the expensive single-purpose tool can find proper employment in but few of our own factories. The employment of the capstan lathe and the milling machine in its various forms in repetition manufacture is a different matter, however, and it is to be hoped that the Olympia exhibition may educate many manufacturers to the possibilities of the larger and cheaper output which these tools offer them.

One may take it that British machine-tool manufacturers build what they can sell, and the fact that the trend of British design appears to be in the direction of universality, and of American design in the direction of specialisation, illustrates the effect of this question with which we have been dealing. As an example, we may refer to the horizontal boring machine which has greatly developed during recent years, and of which many admirable examples are to be seen at the show. The British machines are in every way general-purpose tools, and can bore, face-mill, edge-mill, surface-turn, drill, tap, stud, &c. They are extremely useful tools in the engine shop, but in view of their cost would clearly not be bought by a manufacturer who required a machine only for one constant repetition job. The same sort of thing may be seen in milling machines. These examples do not indicate that the British machine tool-designer is in any way too conservative. Quite the opposite is the case, and evidence of continuous progress and originality is to be seen everywhere. What they do indicate, however, is that the British manufacturer has as yet touched little more than the fringe of mass production.

We have said above that the exhibition indicates much activity in British machine-tool design. This activity may be traced on almost every stand, and it would hardly be going too far to say that apparently every British machine-tool builder has in recent years remodelled and re-designed the great proportion of his products. The general effect of the exhibition is that British machine tools have become more workmanlike and more rigid. There is no doubt a certain amount of fashion in this matter, but certainly the general introduction of modern cutting steels have called for different general proportions in machine tools. In this matter there is no sign of this country lagging. There are certainly lathes, for instance, to be seen which closely recall those of thirty years ago, but an equal, if not greater, proportion of these are of foreign make as of British. In the matter of workmanship and finish the Show also illustrates that our shops have nothing to learn elsewhere. The matter of accuracy it is not so easy to speak about after only general inspection. Many British firms are now showing tool-room lathes, and it is to be trusted that the accuracy of a fair proportion of these is up to tool-room standards. Several firms also show precision lathes of small type. Some of these undoubtedly have an accuracy which justifies the adjectives, but it is unfortunately easy, having constructed a small bench lathe, to paint it a pleasing grey and call it a precision tool. The name, however, will not give it the quality of precision. It would be useful if the Machine Tool Trades' Association, or some other body, could in some way ensure that the word "precision" is not used without warrant.

The exhibition, as a whole, is excellently arranged, and much may be learned there by any engineer. Very many machines are in operation, which adds a feature not only attractive to the general public, but also frequently of value to the technical visitor. We have expressed a hope that both skilled labour and the managerial element will attend. The machine-tool expert and designer we need not worry about. He will turn up in any case. We may mention the foreign buyer, however. It is to be trusted that he will be very adequately represented. Such an opportunity of seeing on a comprehensive scale what this country has to offer in the machine-tool world does not come frequently, and a proper inspection of the various exhibits should be of profit, not only to our machine-tool builders, but to their foreign clients. The state of the American exchange, as far as the European market is concerned, makes the possibility of purchasing modern and in every way adequate machine-tool equipments in this country one of great importance. The foreign visitor to Olympia is likely to find that all his requirements in this direction can be met in the relatively cheap market which this country affords.

THE TRAINING OF YOUNG WORKERS.

THE number of committees formed within the last two years to deal with the subject of the education of young workers in our leading industries and the reports issued as a result of their deliberations may clearly be taken as a sure sign of the increasing interest now being taken in this important subject. That this movement has been intensified by the passing into law of the Education Acts of 1918 is certain, but apart from such influence, it is generally realised that social progress depends largely upon the education of the rising generation, and that industrial success will not be upon a secure foundation for future and continued prosperity unless accompanied by gradual and steady improvements in general conditions. In fact, the whole structure of modern society is so framed that it is increasingly difficult to dissociate purely industrial from general social questions. All the various issues are becoming gradually interlocked and the most sure rock upon which to build hopes for the future is unquestionably that of an improving educational system. Scotland has ever prided herself upon the education afforded to her rising generation and points as proof of its efficacy to her many successful sons in all spheres of activity the world over.

The Education Act of 1918 can almost be looked upon as revolutionary, and it is only natural that very serious consideration should be given to its provisions as against the day when they will require to be met. This Act calls for the setting up of District Boards, representing the principal industries of the area covered, with whom the Educational authorities can deal and consult in relation to the many points that may arise. No one can but desire to move forward, in respect of such a vital path as that of education; but a serious and severe warning must be issued to the effect that the whole world is still suffering the natural consequences of the last few years, and has emerged starved in many vital organs. Only the most serious, consistent, determined and efficient efforts can serve to effect such remedies as will ensure a steady progression without serious relapses. Above all the efforts made must be efficiently applied. There is not energy, time or money available to be frittered away in *cul de sacs* due to division of effort or aim. Nor can all the hopes evidenced in the provisions of these Education Acts be early realised. Time will be necessary even for their partial fulfilment, and the extent of such inevitable delay will in large measure depend upon the heed paid to the opinion of those who do not yield to anyone in enthusiasm for improved educational facilities, but whose primary function at the present time unquestionably is the more urgent one of re-establishing on an economic basis the main industries of this country.

As representing local industries, the Institution of Engineers and Shipbuilders of Scotland formed a standing Committee composed of representatives of the local industrial interests, to consider such matters, and the first part of their report is published. It cannot be said to be unorthodox in character or point of view, but is notable rather for the very careful considerations given to the average boy in industry and to the ways and means recommended for improving present conditions so that they may gradually and finally merge, when required, into the new state imposed by the fulfilment of the provisions of the Act. Quite generally such reports have concentrated too much upon the more studious type of youth. The engineering apprentice who is capable of assimilating instruction, which can be truly described as scientific, is the exception. In this respect the report under consideration is to be commended since both as regards school training and subsequent instruction, a simple curriculum is laid down for the average lad.

Attention should be called to a recommendation to the effect that differentiation in regard to aptitude for study should be made at or about the age of 12 years and that two separate courses of instruction should be available from the age of 12 years to 15 years, the new school leaving age in Scotland, when the Act becomes fully operative. The higher serves for the more studious and the other includes more practical and manual instruction for the more average boy. This proposed system of grading boys at such an early age as 12 years will certainly not be unanimously commended. Inevitably, as must be the case under any system at all, for that matter, a certain number must suffer. This result may be due to many causes, such, for instance, as excessive physical development having stultified latent mental powers of considerable capacity and so relegated an individual to a lower level of training rather than to studies which would enable him to absorb fully the training in the more advanced section. We cannot really altogether regard seriously the proposal to grade boys below the age of 15 years and thus to constrain them to follow one or other of two such different courses as are outlined in the appendices to the report. Apart from the building up of character, all education below the age of 12 or even 15 years, has but a relatively small value, except in so far as it lays well and truly the foundations of good clear thought and inculcates the desire to learn and to assimilate, and develops the mental machinery for doing so. In this work, more depends upon the teachers than upon the curricula, and one of the greatest, if not the most important, advantages of all accruing from the recent Acts is that the higher remuneration of teachers under the new authorities will call into being for selection to fill vacancies men and women of higher attainment, broader outlook, and greater capacity.

In this report it is realised that if the school-leaving age is advanced to 15 years, it is most desirable to allow boys to commence apprenticeship immediately thereafter in order to prevent that disastrous gap between 14 and 16 years of age, at present often the cause of the undoing of much of the good of earlier education, permitting the sowing of seeds of idleness, and the forming of bad habits later found to be difficult if not impossible of eradication. What of the selection of boys for various trades? The subject is only mentioned in the report in connection with Labour Exchange activities in this direction. Experience in connection with the placing of boys in industries conclusively proves that boys are put to trades for the very slightest of reasons, or without reason entering into the question at all. Whimsical fancies of fond but ignorant parents, hearsay, the influence of the father's trade and home associations all play an important part in forming the desire of the parent, which is often strongly held. Either the boy, in considerable ignorance, agrees, or has no opinion whatsoever.

The putting into practice in full of the Education Acts, it is now realised, will impose an extremely heavy burden upon the ratepayers, and, in measuring the value of results, due regard must be given to the gain from the allocation of boys to suitable trades, due allowance being made for supply and demand. This is most surely a vital factor in industrial efficiency now capable of immense improvement. The gain in efficiency resulting from fitting as far as is possible, with the minimum of avoidable errors, square pegs into square holes should call for the efforts of such representative Committees as that of the West of Scotland, and we commend to them this line of development of their activities.

It is realised that evening continuation classes, even with the provisions of the Acts fully in vogue, will remain a strong educational force, and the report calls for a desirable extension and broadening of scope of the subjects dealt with. Day continuation classes conducted by employers, are by no means rare, and have met with considerable and creditable success. Many recommendations are contained in

this report concerning the scope and curricula of these classes as a guide to those about to inaugurate such schemes, or as against the institution of these provisions of the Act; these details should be carefully studied.

In view of the recent inquiry into Labour Exchanges, the short paragraph on this subject has much significance. The point of view of the report is naturally confined to that part of the working of Labour Exchanges that deals with juvenile employment. Of all the aims of those responsible for the policy of such Exchanges, that concerning the placing of juveniles in suitable employment is worthy of the greatest encouragement. On this point the report says:—

"Employers are recommended to make fuller use of Employment Exchanges in engaging apprentices. Attention is drawn to the fact that these Exchanges now have special Juvenile Advisory Committees to assist boys on leaving school to choose their occupation, and to find the employment best suited to their wishes and circumstances. The scope of such Committees is at present restricted by the Ministry of Labour, and more latitude may be given to them in future, depending in part upon the extent to which employers take advantage of their help." There is room for reflection as to whether the Employment Exchange or the educational authorities ought to be responsible for this important function.

In conclusion, it is clear that the attitude of many towards the scheme of education of the 1918 Acts may have changed, due to the fuller realisation of the enormous financial charge upon the community thereby involved, but the subject of the necessity of improved training and guidance of the present and future young workers of our chief industries cannot be gainsaid. The manner in which our large employers of labour have met the needs of the times is generally quite inadequately realised. The amount of thought and care that is bestowed by them upon this side of their duties to their industries, receives little acknowledgement, and the report before us, evidencing such constructive thought with arguments carefully developed deserves grateful recognition and wide-spread attention.

INDUSTRIAL PROSPECTS IN JAPAN.

Of all the belligerent nations Japan was that on which the world war fell lightest. Her military operations were almost confined to the taking of Tsingtau, and her further participation in the contest consisted in the main in supplying her Allies with munitions of various kinds. This transaction quite naturally and justifiably resulted in large profits, and at the same time, Western competition being eliminated in the markets of the East, Japan entered the vacant field. The result has been that Japan, like America, has changed her financial status during the war, and from a debtor nation has become a creditor one.

The development of Japanese industries during the war forms the theme of a report* by Mr. Hugh Horne, Commercial Secretary to our Embassy at Tokio.

The report expresses the fear that as regards the trade in beer, cheap cotton hosiery, glassware, brushes and matches, we shall have a difficulty in recovering the ground inevitably lost during the war. In other departments of trade, however, the Japanese merchant and manufacturer has, in many cases, pursued a singularly short-sighted policy, and has ruined his prospects by supplying goods of very inferior character. As a consequence, the Armistice was followed by a wholesale cancelling of orders provisionally given. The firms in question, moreover, adopted the practice of distributing the whole of the profits made as dividends in place of seizing the opportunity of building up reserves for the extension and improvement of their equipment, and for "carrying on" during possible periods of depression.

The poor quality of much of the exported goods is the more noteworthy in that as regards many commodities inspection prior to export is compulsory. This inspection is made by officials appointed by the manufacturers' guilds, but conducting their inspection in accordance with Governmental regulations. The standard set is, however, very low; so that whilst it is impossible to export absolutely worthless material, the inspection provides no bar against the despatch of goods of very poor quality. As a consequence, the more far-sighted firms do not rely on these official inspectors, but have also inspectors of their own.

Japan is a country which is singularly deficient in raw materials. According to a certain school of economics Japan should accordingly abandon any ambition to become a manufacturing country, but the industrial history of Switzerland shows that the economists who rely on *a priori* reasoning are exceedingly apt to have their conclusions falsified by the facts. Switzerland in the matter of raw materials is worse off than Japan, but this did not prevent the Swiss from establishing highly successful industries, and conducting a large export trade in these, notwithstanding her lack of a seaboard. Japan is, accordingly, much more favourably situated. Minerals occur in great variety, and she can herself supply some of her requirements for those in common demand. The amount accessible is, however, relatively small. Her total reserves of coal are placed at less than 4,000 million tons, of which 800 million tons lie at a less depth than 2,000 ft. below bank. On the other hand, like Switzerland, there is plenty of "white coal" available, and already over one million horse-power are being generated at hydro-electric stations, and official estimates show that another 7,000,000 h.p. can be economically developed. Hence Japan's aspirations towards the building-up of a large trade in manufactured goods will not be handicapped by lack of power. The success of Switzerland has been largely due to the skill of her workmen, who have had an historical reputation for the execution of delicate and accurate work. Japanese workmen have had a corresponding reputation for artistic work, and there is no reason to believe that this deftness may not prove equally valuable when devoted to engineering ends. At present the Japanese workman is said to be relatively inefficient. He prefers to work leisurely and has no objection to long hours.

The pre-war rate of pay for dock coolies was 16*d.* to 18*d.* per day. It is now over 6*s.* per day. Carpenters who received about 2*s.* a day before the war now get 5*s.* 3*d.* a day, and tramwaymen have had their pay raised from about 40*s.* a month to 120*s.* a month.

Were the Japanese workman efficient these low rates would make competition with him impossible, but his relative efficiency as compared with British workmen is said not to be more than one-half to one-third. As elsewhere, cheap labour and high labour costs are frequently associated, for one reason because, when labour is cheap there is little inducement to instal efficient machinery. Such machines are expensive, and the capital charges involved run on during slack times whilst labour costs can be reduced by dismissing hands.

Labour in Japan suffered much from high prices during the war. The Government were slow in regulating prices and in equalising distribution, and in the meantime stocks were cornered by speculators, who only released their hold under governmental compulsion. The rise in the cost of living, in spite of the apparently very favourable situation in Japan, has increased in greater proportion than in this country. In 1919 official estimates show that in Japan the increase was 256·1 per cent. as against 229·4 per cent. here. The facts brought forward in this respect constitute additional evidence that, on the whole, Britain mastered the difficult problem of carrying on during the war better than most of her Allies, although out of consideration for Ireland, the authorities did not carry out the distribution of foodstuffs quite equitably.

As here, so in Japan, the principal sufferers from the increase in costs have been the professional and official classes, and it is perhaps worthy of note that the unskilled dock coolie is now being paid more in Japan than is the skilled carpenter, a condition which recalls recent happenings at home, and which, in the nature of things, can hardly be permanent.

The increase in trade put a heavy strain on the Japanese railroads, of which the mileage is now 9,503. In 1913-14 the number of passengers carried was 167,773,143, and in 1918-19 this had risen to 288,061,584, in spite of heavy increases in fares. The normal third-class fare was about 0·40*d.* per mile before the war. It is now about 0·61*d.* The tonnage handled was 36,348,362 tons in 1913-14, and 53,313,720 tons in 1918-19. The development during the war years is as much as was expected during nearly thirty years of normal development. The plans for railway construction have accordingly been revised, and it is now proposed to spend on the work about 140,000,000*l.* This expenditure will be spread over a term of seven years. There has been a shortage of coal, the price of bunker coal, for example, having risen from the 9*s.* to 11*s.* per ton prevalent before the war to about 53*s.* a ton in 1919. As a consequence, the electrification of certain existing railway lines is under serious consideration. A private company is about to construct underground lines in Tokio.

With its exceptionally long coast-line, much Japanese transport is naturally conducted by water, tonnage amounting to about 806,000 tons being employed in the coastal trade alone. Freights in this service have increased enormously. In pre-war days the Mioji-Yokohama charge was 3*s.* a ton. This rose to 23*s.* a ton in 1915, and is now 10*s.* a ton. The ocean-going freight to Europe reached its maximum in 1917, when it was 455*s.* a ton. In 1919 it was 180*s.* a ton. Road transport, on the other hand, is little developed owing to the indifferent state of the roads. Nevertheless, some 6,000 motor-cars are in service, and there is a demand for 1-ton to 3-ton motor lorries. Important road improvements are foreshadowed in the early future.

The Japanese are anxious to establish dye and chemical industries, and Mr. Horne expresses surprise that the dye manufacturers are to be protected at the expense of the textile manufacturers, since the dye industry is in a very backward stage of development. No doubt this is the very reason for the desire to encourage its development. In part, no doubt, to ensure Japan the possession of plant capable of diversion to the production of explosives and gas shells in case of war, but also in the belief for which history provides ample warrant that present sacrifices may often result in future gains. Our own mercantile marine was built up largely on the Navigation Acts, and it is appalling to think of what the present price of steel would be had its manufacture in America not been encouraged by the sacrifices of a past generation.

* Report on the Commercial, Industrial and Financial Situation of Japan, 1914–1919. His Majesty's Stationery Office. [Cd. 912.] Price 9*d.* net.

NOTES.

A Dutch Information Bureau.

It is not generally known to manufacturers in this country that there is in Holland a semi-official bureau established for the purpose of assisting trade with that country. The body is subsidised by the Dutch Government, and is enabled to give its services free to foreign clients. The bureau is termed the Bureau Voor Handelsinlichtingen, and its address is 16 Oudebrugsteeg, Amsterdam. It will assist British firms in finding suitable agents for their products, and furnishes statistical information, &c. The bureau does not exist for the purpose of giving information regarding the financial status of firms. It will arrange for the free exhibition of foreign samples. The conditions laid down for securing the assistance of this office are simply that the applicants shall prove themselves to be genuine, by giving as references their bank and the names of two other commercial firms of standing. Firms who wish to take up Dutch agencies abroad can also get into touch with suitable Dutch producers through this bureau. In view of the considerable trade of this country with Holland, it would seem that an office of this kind should prove of considerable value to our manufacturers and others, and might be made much more use of than it is at present, if the facilities which it offers were more widely known.

Cases under the Restoration of Pre-War Practices Act, 1919.

Two cases of some importance in the engineering industry were decided by Local Munitions Tribunals

last week under the Restoration of Pre-War Practices Act, 1919. In one of them the Lancashire Ordnance Accessories Company, Limited, of Stockport, were prosecuted before the Manchester Tribunal, at the instance of the Amalgamated Engineering Union, in respect of the employment of women in the machining and grinding of roller bearings. The union claimed that the work should be done by skilled male labour, but the company proved by the evidence of representatives of a number of leading manufacturers of ball and roller bearings that it was not the pre-war practice to employ skilled male labour on the work, and the complaint was dismissed. In the other case, which was before the Nottingham Tribunal, the British L. M. Ericsson Manufacturing Company, Limited, were prosecuted by the Amalgamated Engineering Union in respect of the employment of women in the manufacture of small parts of telephones, on milling machines, small capstans and light power presses. The company had introduced women on the work during the war, and the union claimed that they should revert to their pre-war practice of employing male labour (boys and youths) on the work. The company were supported in their defence by representatives of leading telephone manufacturers in different parts of the country and led overwhelming evidence to the effect that it was in accordance with the general pre-war practice to employ female labour on the work. This complaint was accordingly also dismissed.

Training Mechanics for the Air Force.

A scheme which ought to ensure a good supply of efficient mechanics for the Royal Air Force, and also solve, for many parents, the problem of what to do with their boys, has recently been inaugurated by the Air Ministry. According to this scheme, the sons of British-born parents can enter the Air Force as boy mechanics between the ages of 15 and 16½ years and, after doing so, will receive a three-years' apprenticeship training in one of the skilled trades, as well as an educational course including English, civics, practical mathematics, applied mechanics, mechanical drawing and general science. Moreover, they will be lodged and victualled free, and even receive some pay during their period of training. When the course has been satisfactorily completed, the youth will be promoted to the rank of leading aircraftman, or, if he shows exceptional promise, he may be selected for a specially-extended course and promoted to the rank of corporal. Some may even be offered commissions in the Royal Air Force, and, in any case, youths who have passed through the training course will be specially considered for promotion to commissioned rank during their period of service. In return for this the nation requires the use of their services for a total period of not less than twelve years, two of which would be spent in the reserve. A moderately good standard of general education is required in candidates, who may enter either by open competition, in accordance with the results of an examination to be held annually by the Civil Service Commissioners, by limited competition among the nominees of certain educational authorities, or by nomination of the Air Council subject to a qualifying test. Space does not permit us to give full particulars of the scheme, and this is unnecessary since persons particularly interested can obtain them from the Air Ministry. The outline given above, however, should suffice to indicate its general character. For its complete success much, of course, depends upon the nature of the training given. Skilled craftsmen with special ability for imparting their knowledge to others are essential for the training centres, but such men are rare, and there may be some difficulty in obtaining the requisite number. We have no doubt that sufficient candidates will be forthcoming to meet the requirements of the Air Force, and the men, on the completion of their period of service, should have no difficulty in obtaining useful and remunerative employment in industrial concerns if the training scheme is properly carried out.

Personal.—Professor John Bretland Farmer, D.Sc., M.A., F.R.S., Imperial College of Science and Technology, has been appointed by an Order of Council, dated August 28, 1920, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

THE BRITISH ASSOCIATION.

(*Continued from page* 323.)

Section A.—Mathematical and Physical Science.

Section A well maintained its leading position as the original section of the British Association. The proceedings were of high interest throughout, and the president, Professor A. S. Eddington, F.R.S., of Cambridge, had to exercise his functions with firmness to dispose of the 25 papers and reports on the agenda in four morning sessions. The subject of his own address was astronomical, and communications on astrophysics and geophysics, aurorae, terrestrial magnetism, tides and seismology gave rise to further important discussions. Prominent in many of them was spectroscopical research, which also came up for special attention. Communications on mass spectra and on the constitution of the atom again were so closely interlinked with the other papers that the grouping of the papers is not easy. A few physical and mathematical papers stand more apart. We will arrange the papers irrespective of the order in which they were read. The Section met in the handsome building of the University College, the large lecture hall of which can accommodate more people than can hear well. The officers of "A" were: Vice-presidents, Principal E. H. Griffiths, D.Sc., F.R.S., Professors G. H. Hardy, F.R.S., and A. L. Selby, M.A. (Cardiff); Secretaries, Dr. W. Makower, M.A. (Birmingham) Recorders, Professors H. R. Hassé (Bristol) and A. O. Rankine, D.Sc. (South Kensington), Mr. J. Jackson (Greenwich Observatory), and Captain J. H. Shaxby, D.Sc. (Cardiff).

Professor Eddington did not devote his very able address to relativity, as seemed to have been expected, but to astrophysics. We subjoin an abstract of the address without comments.

The Internal Constitution of the Stars.

Last year at Bournemouth Sir Charles Parsons had proposed to bore a hole 10 miles deep into the crust of the Earth. That proposal, Professor Eddington remarked, reminded us that the most secret places of Nature were perhaps not 10^8 miles above our heads, but 10 miles below our feet. The work of Shapley on globular clusters, at distances scarcely dreamt of hitherto, seemed to make our knowledge of those remote clusters in some respects more complete than that of the local aggregation of stars including our Sun. The theoretical researches [on gravitation] of Einstein and Weyl rendered it probable that the space which remained beyond was not illimitable. He would devote his address to analytical boring devices, looking for something easier to penetrate than rock, viz., matter in the state of a perfect gas. Stars in that state existed in great numbers, although they might at first sight be scarcely distinguishable from the dense stars like our Sun. That the gaseous stars like Aldebaran, Canopus, Arcturus, &c., perhaps made up three-quarters of the naked-eye stars had been shown by H. N. Russell and Hertzsprung, and it formed the outstanding feature of recent progress in stellar astronomy.

The diffuse gaseous stars were called *giants*, the dense stars *dwarfs*. A star seemed to begin its life as a giant of comparatively low temperature, a red star of the M type. The diffuse mass contracted until it became too dense to behave as a perfect gas. A maximum temperature was attained depending upon the mass; the star, then a dwarf, cooled and contracted further; thus each temperature level was passed through twice, in an ascending stage as a giant, and in a descending stage as a dwarf. These stages were not discriminated originally, so that the classification led to perplexities. But the great differences in luminosity particularly of the red and yellow stars, where the two stages fell widely apart in the history of the star; the differences in the stellar density, which we could determine in eclipsing variables like Algol; and finally the spectral differences observed by Adams and Kohlschütter enabled us clearly to distinguish between the ascending and descending stages, though we should perhaps not too hastily assume that the evolution was necessarily in the order of increasing density. The giant star had a far larger surface than the dwarf and gave correspondingly greater light. In a giant a mass comparable to that of the Sun was swollen to a volume of a low density, often below that of our atmosphere. In such giants energy existed in two forms. In red-hot iron the heat was all energy of motion of material atoms, and perhaps only one billionth of the total energy consisted of ether waves. As the temperature rose, the material energy increased with the first power of the temperature, the ethereal energy with the fourth power. In the giant stars more than half the total energy was imprisoned radiant energy trying to escape; like a sieve the star could only retain the energy temporarily, though an element of energy might be scattered, absorbed and flung about in the star for hundreds of years before it escaped into space. The giants differed from one another, but the two forms of energy seemed to be balanced in all of them. In the early attempts of Lane, Emden and Ritter heat had been imagined to be carried to the surface from the interior of the star by convection. That the problem was radiative, that we had to explain why the heat did not leak away, had been recognised by Sampson in 1894, and the equilibrium theory had been worked out for the Sun by Schwarzschild. The outflowing stream of energy was powerful enough to exert a direct mechanical effect on the equilibrium of the star; that stream really was a wind, for though ether waves were not material, they had mass and momentum, and part of the pressure on the gas in the interior was borne by the force of the wind, the radiation pressure.

Assuming always that the star material were sufficiently rarified to behave as a perfect gas, two properties of the material concerned us, the average molecular weight and the transparency or permeability to radiant energy. At high temperatures we were dealing mainly with radiations of 3 to 30 Angström units, very soft X-rays. The absorption experiments of physicists were made with harder rays, and to estimate the absorption we had to know the molecular weight. Since in stars the particles were probably highly ionised, the *average* molecular weight would be low, because each free electron counted as an independent molecule for this purpose. If we accepted the value 2 as the minimum average molecular weight and infinity as the possible maximum, the mass coefficient of absorption, expressed in c.g.s. units, could only range from 10 to 130. From thermodynamical considerations 35 c.g.s., corresponding to an average molecular weight of 3·5, seemed to be a likely average. This was of the order of magnitude of absorption measurements made on X-rays in our laboratories. Though now giants differed widely in temperature and density, the absorption of the hottest and the coolest stars seemed to be practically equal, and that was surprising also when we considered that absorption was not continuous, but took place in quanta; there was a limit to the amount of absorption, and saturation might be reached in stars, though not in our laboratories. Those difficulties might be met if we assumed with Barkla that stars depended upon scattering rather than upon atomic absorption. If the opacity were considered constant, the total radiation of a giant (roughly measured by its luminosity) should be a function of the mass independent of temperature and diffusedness, and that would agree with Russell's fundamental observation, that giant stars of all spectral types had nearly the same luminosity. The masses of giant stars were also remarkably alike, as we knew from double star work, the variation hardly exceeding 3:1, and with the aid of observation of our Sun (a dwarf) we could calculate the maximum temperatures attained by different masses. Thus to reach the lowest spectral type M a star should have at least one-seventh of the mass of the Sun (smaller dwarfs were not known, fortunately), while to reach the hottest B type the mass should at least be twice that of our Sun. It was further possible to calculate the difference in the brightness of giants and dwarfs of the M type, *i.e.*, stars at the beginning and end of their career. If theory told us that a star of the Sun's mass would reach a maximum effective temperature of 9,000 deg. C. (6,000 deg. being the Sun's temperature), we should hardly be

able to check that estimate; but a figure like 20,000 deg. (hotter than any star) would indicate error.

The greatest need at present was the measurement of the apparent diameters. If we divided the total apparent brightness by the surface brightness we arrived at the angular area subtended by the star; the unknown distance did not come in, because surface brightness was independent of distance. The star of greatest apparent diameter, 0·051 second of arc, seemed to be Betelgeuse; other figures were Antares 0·043, Aldebaran 0·022, Arcturus 0·020, Sirius 0·007. At Mount Wilson, measurements of the separation of double stars were now made (by the interferometer) which brought 0·050 second of arc well within our reach.

Coming back to the radiation pressure exerted by the outflowing heat Professor Eddington pointed out that, assuming an average molecular weight of 3, the fraction of weight which the radiation pressure would support was 0·044, for a star of 0·5 the Sun's mass; for a mass five times that of the Sun, the fraction was 0·457; and if the molecular weight were 5, the fractions would be 0·182 and 0·645. Now 90 per cent. of the giants probably had masses between 0·5 and 5 times that of the Sun, and in that range then the radiation pressure rose from insignificance to importance. The study of radiation brought up the question: what is the source of the radiation which the stars are continually squandering? The answer almost unanimously given was that the energy was obtained from the gravitational energy converted as the star steadily contracted. But the answer was almost as unanimously ignored in its practical consequences. On that hypothesis, due to Helmholtz, Kelvin had dated the age of the Sun back 20,000,000 years, and geologists and biologists tried to accommodate themselves to that scale. Yet George Darwin, in his theory of the Earth-Moon system, Strutt (the present Lord Rayleigh) in his estimate of the ages of rocks from occluded helium, and others did not hesitate to carry the history of the Earth back far beyond the formation of the solar system. The consequences of the contraction hypothesis were particularly serious for giant stars, which radiated heat at least 100 times as fast as the Sun did. A giant would squander, in less than 100,000 years, heat that would sustain the Sun for 10,000,000 years. In 18,000 years a star of type M would reach the G stage, in 80,000 years the A stage near the top of the scale, then to start on the downward path. Did we dare to suppose that all the giants were formed within the last 80,000 years? Some clusters showed us what probably had been passing on 200,000 years ago. There was a class of stars, the Cepheid variables, suggesting that change proceeded far more slowly than the contraction hypothesis allowed. The light of these stars fluctuated in a characteristic way, generally with a period of a few days. This light change was not due to eclipse effects as in double stars; the orbit was too small for a companion, and the change in the colour quality between maximum and minimum pointed to a pulsation intrinsic in the star, a mechanical pulsation of the star (Shapley). If a star were contracting, its period could not remain constant; the period of α Cephei should decrease by 40 seconds annually, but that star had been under observation since 1785, and practically no change of period was noticed.

Thus we would have to give up the contraction hypothesis, and we had to look for another source of energy. That source was to be found in the sub-atomic energy. According to Aston [we shall notice his communication in due course] all the elements consisted of hydrogen atoms bound by electrons. Helium, *e.g.*, consisted of four hydrogen atoms and two electrons. But the mass of the helium atom was not quite equal to the mass of four hydrogen atoms, and in so far, at any rate, chemists agreed with him; there was, in the helium synthesis, a loss of mass of 1 in 120. Now mass could not be annihilated, and the deficit represented the electric energy set free in the transformation. Rutherford had effected such transformations in the Cavendish Laboratory; what was possible there, might not be too difficult in the Sun. The stars seemed to be the crucibles in which the lighter atoms, abounding in the nebulæ, were compounded into the more complex elements. The radioactive elements must have been formed at no distant date; their synthesis, unlike the generation of helium, was endothermic. If combinations requiring addition of energy were possible in stars, combinations which liberated energy ought not to be impossible, and if only 5 per cent. of a star's mass consisted originally of hydrogen atoms, which were gradually compounded into complex elements, the total heat liberated would more than suffice for our demands. We need not bind ourselves to the formation of helium from hydrogen, however. It was a question of accurate measurements to determine the deviation of the atomic weights from integers. Up to the present hydrogen was the only element for which Aston had detected the deviation; but we should learn more about the possibilities. We might not know the source of stellar energy with certainty. But the liberation would be determined by the high temperatures of the hottest interior (Russell), and the more concentrated the supply, the smaller would be the opacity required for the radiation observed.

Concluding, Professor Eddington remarked that his address might be considered highly speculative from beginning to end. But to speculate was not the same thing as to make hypotheses; hypothesis limited speculation. If the mathematical physicist worked out the behaviour of an ideal model of specially defined properties, his work might be unimpeachable, and no more speculative than the binomial theorem. But he began to speculate when he suggested that his toy was like something going on in Nature. Yet factors disregarded would betray themselves by comparison with Nature; and the failure of the model need not cause disappointment. "In ancient days two aviators procured to themselves wings. Daedalus flew safely through the middle air across the sea, and was duly honoured. Young Icarus soared upward toward the sun till the wax melted which bound his wings . . . Yet there is something to be said for Icarus; he brought to light a constitutional fault in the flying machine of his day; Icarus will strain his theories to the breaking point till the weak joints gape."

In proposing the vote of thanks, which Professor A. L. Selby seconded, the Astronomer Royal, Sir Frank Dyson, said that astronomy had become a very wide-reaching science, into which Professor Eddington had brought a unique knowledge of mathematical physics.

The Nova Cygni.

The new star, which Mr. W. F. Denning discovered in the night of August 20, the Friday before the meeting, twice interfered with the proceedings of Section A. When Professor Eddington had delivered his address, Sir Frank Dyson interposed to inform the Section that they had on Saturday observed the Nova at Greenwich, so far as the clouds permitted, and found it to be of magnitude 3·5, as Denning had stated, a pale yellow star with a continuous spectrum and some bright lines. On Sunday Dr. W. J. S. Lockyer, at Sidmouth, had noted an increase in magnitude to 3, and a spectrum resembling that of Cygni. The Greenwich star maps certainly showed no star of magnitude above 14 in that region. Professor H. H. Turner added that the Oxford and also the Cambridge Observatories had not been fortunate, but they would all be delighted that this great discovery had fallen to Mr. Denning—now old and in feeble health—after many years of concientious work, whilst hundreds might claim the honour of having discovered the Nova Aquilae in 1918. Professor Eddington further emphasised that Denning's discovery was not a matter of luck. Father Cortie was sorry to have to say that they had at Stonyhurst been misled by a mistake made in the telegraphic communication of the right ascension.

On Friday, Professor A. Fowler was able to announce that the star had been seen by the Astronomer Royal and himself at the Cardiff Meteorological Observatory the night previous. The magnitude, which had apparently been at its maximum, namely a little below 2, on Wednesday, was then already down to 2·8 again. Dr. Lockyer's spectrum which he exhibited, distinctly showed the hydrogen and calcium lines, also magnesium and iron; these lines were generally dark first in new stars, then brightened up on one side, the enhanced lines becoming more diffused and finally bright. In this case the rise to maximum brightness seemed to have been slower than usual.

Spectra of Nova Aquilæ III.

Colonel F. J. M. Stratton's communication on the Spectra of Nova Aquilæ was, in Professor Eddington's words, very upsetting to preconceived ideas. Exhibiting photographs, obtained by J. H. Moore at the Lick Observatory with the single prism spectrograph and the 36-in refractor, Col. Stratton remarked that very peculiar changes were going on in the distribution of the radiation from the originally greenish disc which was apparently growing in diameter. Judged by the Hβ line the disc was only growing at half the rates given by the nebular lines N_1 N_2, while the complex bands in the spectrum corresponding to all the three lines gave the same multiple effect of the wave length for the displacement of separate maxima. The bands were of curious shape, and the maxima corresponding to the upper portion of the disc did not coincide with the maxima from the lower portion of the disc, and were differently inclined, as if they originated in different portions of a system undergoing a very complex combination of expansion and rotation or vortex motion. Assuming that these facts should be explained by the Doppler effect the hydrogen and the nebular gas seemed to flow out at different rates. While the maxima remained fixed in position, the most displaced lines were growing brighter by comparison to the central line. It looked as if the nebula had turned into a ring or spiral in less than two years. Father Cortie commented upon these extraordinary results which, Professor Eddington thought, might be due to two bodies revolving about one another after having collided.

Shift of Fraunhofer Lines and the Einstein Theory.

Mr. J. Evershed, F.R.S., of the Kodaikanal Observatory, India, gave a detailed account of the researches on the shift of the Fraunhofer lines in the Sun which had been conducted in that observatory since 1913. The work, he explained, had been started before the shift of the Fraunhofer lines had been recognised as a crucial problem for the relativity theory, in order to determine, in the first instance, the effect of pressure on the shifting of the lines. Measurements of the sun-spot spectra had shown that pressure effects were small if at all present in the umbræ; but large displacements were observed in the penumbræ, and the study of the lines of hydrogen and calcium indicated a radial movement outwards from the spot centre. The results suggested that motion, rather than pressure, might be concerned in the general shift towards the red. The shift had first been assumed to indicate a pressure of about 6 atmospheres in the reversing layer. The researches still being continued suggested, however, that the gases giving the lines must be in a state of almost inconceivable tensity, and effects of pressure and density were hence improbable. Measurements on 136 iron lines were strongly in favour of motion and against pressure. Thus high level lines showed larger shifts than low-level lines; strong pressure shifts observed in the laboratory were comparatively weak in the Sun; and the average shift did not increase with the wave-length in the Sun, whilst the pressure shift in arc experiments increased with λ^2 or λ^3.

For the south limb of the Sun, on the other hand, the results of their observations were remarkably close to Einstein's prediction. There were discrepancies, however: calcium and magnesium lines showed smaller shifts than the iron lines, whose displacement did not increase with the wave-length as it should; faint lines were more affected than strong lines, moreover, and the effect was not uniform across the disc. For these reasons Mr. Evershed was inclined to ascribe the displacements observed, not to Einstein's theory, but to a peculiar kind of motion effect which he had tentatively suggested in 1916, though himself considering it almost incredible at the time. Relying mostly on

the iron lines, he assumed that the iron vapours on the Sun were driven away from the Earth, as the gases in a comet were driven away from the Sun. To test this assumption he made observations on Venus when in front and behind the Sun, though in both cases, of course, at a considerable distance from the one or the other side of the Sun. In these various positions Venus would more or less be illuminated, in the one case by light from what appeared to us the front of the Sun, in the other case by light from the back of the Sun, this light being reflected back to us. If we understood correctly—Mr. Evershed did not particularly explain this point, dwelling more on the details of his large number of slides—he did not observe any decided recession of iron vapours from Venus, the evidence being rather discordant. Yet his summary was that his observed displacements did not indicate an Einstein effect, but rather an effect of motion due to some peculiar influence of the Earth. He found support for this view in Maunder's observation that the Earth seemed to influence sun-spots and faculæ. Like C. Saint John (Mount Wilson), to whose similar work on the displacement Mr. Evershed referred repeatedly, he hence concluded that we were not in a position to decide for or against Einstein.

In thanking Mr. Evershed for his communication, Professor Eddington remarked that after all Einstein's assumptions seemed simpler than those suggested. The effects are exceedingly complex and would partly compensate one another.

Controversial Note on Popular Relativity.

Mr. Evershed had only referred to one of the predicted consequences of the relativity theory, without dwelling upon the general theory, but Sir Oliver J. Lodge in his "Controversial Note on Popular Relativity" confined himself, in the first part of his communication, to a definite physical point, while he attacked relativity in general in his conclusion. Sir Oliver Lodge contended that there was no experimental evidence for the dogma that the wave fronts, initially concentric to the source of radiation and to an observer at that centre, really remained concentric when the observer travelled. The Michelson-Morley experiment was consistent with such concentricity, but did not necessitate it, and the Fitzgerald-Lorentz contraction of matter in motion would in any case give a perfectly valid alternative explanation. Einstein's equation might be interpreted in various ways, and it was safer for physicists to postulate, in their interpretation, a special property of matter than to foist complication upon space and time. When Einstein asserted that any system of axes of reference, stationary or moving, was as good as any other, that was kinematically true. But to say further that the velocity of light must appear constant to any observer, no matter what he was doing, was not reasonable. If the observer were originally at the centre C of a circle (representing the wave-front) N.E.S.W., and the ether drifted in the direction W.E., the centre C would appear to shift towards W. One might also imagine the circle to be drawn out to an ellipse with long axis N.S., because if we placed mirrors at the four cardinal points, the light would take longer in travelling forward and backward in the direction N.S. than in the direction W.E. Sir Oliver added that he had recently discussed the problem with Michelson, who agreed with him. We could only experiment with matter, not with abstract space, and though he admired Einstein's equations, he considered their interpretation nonsense.

The Section welcomed this criticism as warmly as it called for a reply by Professor Eddington, who responded reluctantly. While agreeing with Sir Oliver that the ether interpretation was one of the possible interpretations, he protested against charging Einstein with having given a "metaphysical theory of space and time." That charge recoiled back; Einstein dealt with the indications of measuring rods and with the interval between the emission and the arrival of the signal. It was metaphysical to speak of the same instant.

Solar Faculæ and Calcium Flocculi.

The Rev. A. L. Cortie, S.J., of Stonyhurst, presented a communication on a "Comparison of Drawings of Solar Faculæ and Photographs of Calcium Flocculi," most of the drawings exhibited being based on direct observations made during the last forty years by Brother William McKeon, of Stonyhurst, and the photographs and spectroheliographs taken there and elsewhere. Father Cortie admitted that the two phenomena were not directly comparable in so far perhaps, as the faculæ were best visible near the limb, whilst the flocculi were more distinct in the central regions. But he pointed out that the general grouping of faculæ and flocculi, as well as the individual ramifications of both the phenomena justified the assumption that faculæ and flocculi were really different aspects of the same outbursts, the latter showing the clouds of calcium vapour in the upper strata. The H and K lines of the flocculi were also observed in the faculæ, near the sun spots or detached from them. As the sun-spot disturbances were repeated near old spots for a year or more, the centre of activity was probably deep down in the Sun. Commenting upon the communication, Sir Frank Dyson remarked that the comparison based upon so abundant material, certainly seemed advantageous.

Terrestrial Magnetism, Auroræ and the Upper Atmosphere.

Professor S. Chapman, F.R.S., late of Greenwich Observatory, now of Manchester, presented an analysis of records exemplifying the relations between "Terrestrial Magnetism, Auroræ, Solar Disturbance and the Upper Atmosphere," based upon thousands of daily records from Greenwich and other British stations, from Pavlovsk (near Petrograd), the Antarctic (Chree's analysis) and from other stations. He pointed out that we have to distinguish (*a*) the regular daily variations of magnetically quiet days [five are selected per month to take averages] and (*b*) the irregular disturbance variations of intermittent changes sometimes increasing to magnetic storms. Though not quite independent of one another, the (*a*) and (*b*) could be traced to different causes. Neither were produced by any direct magnetic action of the Sun or Moon, but both were due to the electromagnetic induction produced by variations in the magnetic fields of roughly horizontal electric currents flowing in different layers of the ionised atmosphere; there was no electrostatic field, and the cause of the permanent terrestrial magnetism was still unknown. Both the Sun and Moon were concerned in these various currents. The Moon caused a true tidal motion in the atmosphere, the Sun a more thermal effect, and these effects, together with the Earth's field, were responsible for the (*a*) variations, and their semi-diurnal character. In Professor Chapman's charts the Earth appeared as seen from the Sun or Moon, in order to show the afternoon and morning hemispheres respectively to the right and left of the meridian, rather than the day and night hemispheres. The rotation of the Earth and Sun, and the revolution of the Moon being all in the same direction, the current and variation curves were symmetrical and simpler than might be expected, though the inclination of the Earth's axis introduced a complication. Compared with the intensity of the terrestrial field, the variations were small. A quiet day at one station was a quiet day everywhere, and a disturbance would affect places on the same meridian simultaneously. When vector diagrams of the magnetic elements were drawn, the summer diagrams enclosed much larger areas than the winter diagrams. The seasonal effect was striking for Pavlovsk, and the Kew diagram was smaller than the Antarctic diagram. The monthly mean diagrams were nearly circular. The diagrams for the lunar phases all showed a small loop within a big loop, the position of the former shifting with the lunar phase. At Greenwich the June (*a*) diagram for sunspot maxima enclosed that for sunspot minima, the two being very similar. The corresponding December diagrams formed much smaller areas within the contours of the June curves, and were more round in shape. Great (*b*) disturbances often repeated after 27 days. The aurorae were due to negatively charged particles ejected by the sun into our atmosphere, deflected into polar regions by the magnetic field of the earth. They were most frequent in the late afternoon (at about 8 p.m.); the corpuscular radiation producing them came apparently from local areas of the sun, not from the surface generally. The (*a*) variations were caused by ethereal radiations of ultraviolet light, not deflected by the Earth's field. The (*b*) changed little from day to day, but became strong in sunspot years. The solar influence on the (*a*) could not be ascribed to ultraviolet light and to the atmospheric ionisation it caused, since that ionisation was greatest in daytime. There must be streams of particles calling forth local ionisation and expansion of the ionised air upward, inducing electromotive forces. If the (*a*) and (*b*) were caused by changes in the same atmospheric layer, any (*b*) should generally intensify the (*a*). That was not so, and we had to distinguish two layers. The higher layer of the auroral phenomena was probably at heights ranging from 90 km. to 300 km. (average 120 km.) above ground. Beneath that layer, down to the troposphere (the first 10 km. or 15 km. above ground), was the layer for the (*a*) variations. The higher atmosphere also contained ozone, which was one of the factors deciding to what depth the various radiations could penetrate into our atmosphere.

The Rev. A. L. Cortie did not accept Professor Chapman's conclusion that the streams of particles reached the earth as such. Exhibiting the curves of the severe magnetic storm of March 22 to March 24 last, when the vertical force varied by 2 deg. 40 mm., he remarked that the storm broke out before the stream from the sunspot was vertical. The stream seemed to have been tangential to the Earth, in fact, and he suggested that the particles ejected by the sun would not travel as a definite stream, but would, owing to the repulsion between the particles, spread out in a cloud, into which the earth entered. The air would then be ionised and be rendered more conductive. The ionisation of the upper atmosphere might be increased at successive presentments of the disturbed sun-spot area, due to accretions to the clouds, until a great magnetic storm was precipitated. The conditions for a great magnetic storm were a disturbed sunspot area, a favourable heliographic position of the earth, and a highly charged condition of the upper atmosphere. His own studies for 30 years in the comparison of long-continued solar disturbances, magnetic storms and the coronal plumes which diverged from such disturbed areas led him to believe that the electrified particles existed in the form of clouds in space.

Professor Chapman in his reply said that he could not accept the possibility of an accumulative ionisation considering that the ionisation changed rapidly as the day passed into night.

Seismological Investigations.

The twenty-fifth report of the Committee on "Seismological Investigations," was abstracted by the Chairman, Professor H. H. Turner, F.R.S. The books and apparatus of the late Professor John Milne, Professor Turner stated, had been removed from Shide to the University Observatory at Oxford, near which Dr. Crombie had supplied a small house for the staff, whilst the instruments had been erected in the basement of the Clarendon Laboratory. This arrangement was approved by the Cambridge Committee, pending any arrangement for a Central Seismological Bureau [formerly at Strassburg under Hecker], to which Professor Turner did not refer. The report further dealt with the study of the earthquake periodicity of long period Chinese earthquakes.

Mr. J. J. Shaw, of West Bromwich, Secretary of the Committee, then gave his report on "Microseisms," faint never-ceasing tremors, for the study which the International Seismological Congress of Manchester, 1911, had granted 500*l.* and on which Strassburg had been expected to report in 1914. The cause of these tremors (possibly wind or sea waves) was not settled. Mr. Shaw thought that observations at two stations some distance apart, but not too far for identifying the individual waves, would be serviceable. He therefore placed one Milne-Shaw machine in his cellar and the other two miles away in a dug-out, a tunnel driven 60 ft. into a pit bank, 15 ft. below the surface, situated 17 deg. west of north of the home station. The microseisms of these two machines seemed at first to be practically identical and occasional apparent differences (up to 2 sec.), due to faulty synchronising. Mr. Shaw then arranged his photographic shutter-slit (over the recording drum) in such a way that a

feeble light always passed, but that the opening fell near the zero portion of a wave (not on a crest or hollow), when it was more easy to take measurement on the ghost-like wave trace produced. Then time differences of about 0.8 sec. were observed, the waves ranging in length from 8 miles to 16 miles and in period from 4 sec. to 8 sec. (mostly 4·7 secs.), the period increasing with the wave-length. The instrument in the dug-out was always reached first by the waves, though the wind direction and velocity varied greatly. The microseisms were stronger at Bidston and Edinburgh (both hill stations close to the sea) than at Bromwich; but at Shide, which is only 6 miles from the sea, they were not strong either, the station not being on a hill. The experiments are to be continued with three stations at greater distances. Sir Napier Shaw, late Director of the Meteorological Office, remarked during the discussion that the Gallitzin instrument at Eskdalemuir gave miles of records (horizontal force in two directions). Though very sensitive, the instrument was very expensive, and several simple instruments of the type which Mr. Shaw had so much improved had their advantages.

We may add that, visiting the Meteorological Observatory at Cardiff during the meeting, Mr. Shaw was able to put the seismograph right, with the result that the instrument recorded two earthquakes that same night.

TIDES.

The report of the Committee on Tides comprised two communications, by Professor J. Proudman, D.Sc., dealing with "Harmonic Analysis," and by Dr. A. T. Doodson, dealing with "Prediction." Both these gentlemen are connected with the Tidal Institute of the University of Liverpool, the former as Honorary Director, the latter as Secretary. The Institute was founded in March, 1919, with funds provided by Sir A. A. Booth, Bart. and Mr. Charles Booth (chairmen of the Cunard and of the Booth Steamship Companies), for tidal research (also for commercial bodies), and also to serve as a training school of applied mathematical research and a bureau for organised tidal information. The Institute keeps in touch with the official bodies and the harbour authorities of the United Kingdom, India and Canada, and with the Coast and Geodetic Survey of the United States, and has received very substantial assistance from the British Association.

The tidal predictions for Liverpool, it was stated, are made by two machines of the Kelvin type, and are prepared, the one by the Admiralty, the other by the United States Survey; the two predictions often differed by 1 ft. and by 3 ft. from the actual tides. At Belfast, Holyhead and Queenstown similar discrepancies were frequent. The most serious difficulty was the prediction of the meteorological irregularities, and the effects could hardly be investigated until we know what the tides would be without them. Having found the harmonic analyses in use unsatisfactory, Professor Proudman now presented a long report, which is to be printed *in extenso*.

Dr. Doodson had found that the predicting machines were susceptible to serious errors, and he had developed a scheme for carrying out the computations involved in harmonic prediction keeping computative labour within reasonable bounds. The intensive study had so far been restricted to the records for Newlyn, near Land's End. There the "shallow-water problem," the elimination of the often disregarded shallow-water constituents, had been solved and other important modifications had been adopted, approximate values for the five most important constituents being, in the first instance, inferred from the analysis of neighbouring stations. Prominent quarter-diurnal constituents were thus revealed, and after removal of these and of the semi-diurnal constituents, the tidal range was finally reduced from 18·5 ft., *e.g.*, to 1·5 ft. Dr. Doodson had also studied the seiches of Lake Geneva, *i.e.*, the oscillations of the Lake level due to differences of atmospheric pressures over the ends of the Lake.

A CENTRAL GEODETIC INSTITUTION.

The "Urgent Need for the Creation within the Empire of a Central Institution for Training and Research in the Sciences of Surveying, Hydrography and Geodesy" was discussed in a joint meeting of Sections A and E, Geography, under the presidency of Mr. J. Macfarlane, M.A., President of E. The discussion was opened by Dr. E. H. Griffiths, F.R.S., of Cambridge, late Principal of University College, Cardiff. The memoir, prepared by himself and Major E. O. Henrici, R.E., pointed out that many British maps and charts were inaccurate and incomplete, and that much labour and money was wasted in revisions, because the work was not done systematically and was badly recorded. That did, of course, not apply to the United Kingdom and to the Ordnance Survey Maps, but just on account of our own excellent maps the interest taken in the question of survey stagnated. Moreover, the maps of the Bristol Channel, the approaches to Liverpool, to the Clyde, &c., badly needed revision, and some survey work of the East Coast went back to 1830.

When the Cadastral Survey of Egypt was finished in 1908, after ten years' labour, Captain H. C. Lyon had to report that 40 years of surveying had preceded their own work in Egypt since 1813, but detailed information as to methods and operations was lacking. The methods varied with the problems of the district and detailed information, so far as published, was little accessible. The Colonial, Indian, and Dominion surveying departments and Institutes were independent, each training its own staff. Hence the need of a central Institution in which the subject could be studied as a whole and which would serve as a central information bureau. It might be suggested that survey and hydrographic charting were Government matters, especially as there was a Colonial Survey Committee; but the various departments had to attend to their own needs and were generally too short of funds for research. The improvements of late years, such as invar tape and superior levelling instruments had come from France and Germany.

Vast tracks of the world and the Empire remained unsurveyed or very inadequately surveyed and charted. Such were the coast of Brazil, the approach to Monte Video, the Falkland Islands, the Straits of Magellan, the Straits Settlements, the Red Sea, the Dardanelles, the Black Sea, and the Grecian Archipelago. There was no school for instructing hydrographic surveyors in the principles of their work. The hydrographic staff of the Admiralty was recruited from volunteers among the young executive Naval officers, who learned while at work on surveying ships and returned to other duties after a few years. The principles involved in the survey by land or sea being the same, and the instruments being largely the same, one institution could usefully study and give instruction in both sides of the work. Both, however, were real branches of geodesy, the problems of which called for high mathematical skill. Interconnected with these problems were further the phenomena of the tides, terrestrial magnetism, seismology and geology, to be summed up in the term geophysics. While a knowledge of geophysics was not necessary for every surveyor, no survey authority could function without it, but no such authorities had a staff available for its proper study. The need for a British Geodetic Institute was, indeed, admitted. The study had so far been left in characteristic British fashion to individuals or had been neglected. The tides, for instance, had received little attention since the death of Sir George Darwin, until Professor Horace Lamb had, at the request of the British Association, reviewed the whole situation in a report in which he strongly urged the needs of an institute to deal with the higher geodesy. The conjoint Board of Scientific Societies had fully recognised this need, and a thoroughly representative Committee had been formed which, in its appeal, had stated: "It would be a matter for regret if, from omission of the relevant scientific development at home, British official surveyors were again compelled to rely on the Prussian Geodetic Institute at Potsdam for information with regard to international work in the higher geodesy." Admiral Parry, then hydrographer of the Navy, the Army Council, and others, supported the appeal, and Sir Charles Close, Director-General of Ordnance Survey, advocated the establishment at Cambridge of a geodetic institute and of a professorship on geodesy. They now awaited, Mr. Griffiths concluded, the advent of the *pius benefactor*—for the institute would have to be established by private benefaction, although assistance might be forthcoming from national funds. The wide ramifications of survey, geodesy and geodynamics into mathematical, physical and engineering sciences called for their study in a university rather than in a departmental atmosphere—for the benefit of the cause, the men and the universities, as Sir Joseph Larmor had emphasised.

Speaking privately, though sure of the support of the War Office and Admiralty, Major Henrici said that it was very difficult to obtain any information form the bulky official statistics which were not indexed. The best books on the subjects and the periodicals were, moreover, German; there was no publication of the kind over here. He pleaded for a school, an information bureau and a periodical, and the best place for the Institution seemed to be Cambridge. Professor H. H. Turner (Oxford) laid stress upon the fact that this was thoroughly a British Association movement. While regretting that the original project of an institute of geophysics had been restricted to the scheme as outlined, he cordially supported the selection of Cambridge. Sir Frank Dyson proposed that the memoir of Dr. Griffiths and Major Henrici should be printed *in extenso* in order to bring the problem into general prominence. This was seconded by Mr. F. E. Smith, F.R.S., director of Scientific Research at the Admiralty, who pointed out that the Admiralty hydrographers were very busy. That was partly in reply to one gentleman who thought it a pity to suggest a rival institution to the universities, which had already every facility, and to the training institutes of civil engineers which taught surveying. Sir J. Ogilvie also submitted that we should know particulars before going further, and that research work should not be centralised. Dr. Griffiths rejoined that they pleaded in the interests of higher geodesy, for which we possessed no institution, and the proposal was passed unanimously.

MASS SPECTRA AND THE CONSTITUTION OF CHEMICAL ELEMENTS.

Dr. F. W. Aston, of Cambridge, gave a succinct and clear summary of the remarkable results he has obtained by modifying Sir J. J. Thomson's method of positive-ray analysis. Our readers are acquainted with the method and with the chief results from Sir J. J. Thomson's recent lectures* on "Positive Rays." By placing the photographic plate nearly horizontal and by deflecting the pencil of rays through almost 180 deg., instead of 90 deg., Dr. Aston succeeds in producing wide separations of his lines for which he claimed an accuracy of 0·1 per cent. Many of the large number of elements he had so far examined (as such or in compounds), he stated, were not pure but had isotopes, *i.e.* elements identical in properties and apparently inseparable, but differing in atomic weight; hydrogen, helium, carbon, nitrogen, oxygen, and further phosphorus and arsenic seemed to be free of isotopes. He gave particulars concerning chlorine (masses 35 and 37, not 35·46, the atomic weight accepted by chemists, bromine (79 and 81, not 80); boron (11 and 10), silicon (28, 29, possibly 30); sulphur, (32, 33, 34), mercury (202, 204, &c., 5 or 6 isotopes), &c. All the elementary masses were found to be integers. The cases of hydrogen and helium were difficult, because there were no reference lines near them. By exposures made with the electric field plates first in parallel, and then in series, however, with potentials of 250 and 500 volts respectively, *e.g.*, masses having an exact 2 : 1 relation should be brought in coincidence on the plate. Those coincidences might not be sharp; but if we first added a small potential, and then subtracted the same, using *e.g.* (500 + 12) and (500 — 12) volts, the original lines should appear bracketed by two others. Thus, in mixtures of hydrogen and helium, the H_2 (hydrogen molecule) line was found exactly between two H atom lines, showing that the mass of the H molecule was twice that of the H atom. When this was applied to the helium line He, and the magnetic field, so far kept constant, was increased, the bracket was no longer symmetrical, *i.e.*, the He line appeared closer to the H line on the left or right, according as the potential was increased or decreased. From the measurements it resulted that

* See particularly ENGINEERING, March 12 last, page 335.

the mass of the hydrogen atom was 1·008, and thus not an integer; in this respect hydrogen differed from all the elements, among which, indeed, it occupied a unique position. The heavy elements seemed to be extraordinarily complex. To distinguish the isotopes Dr. Aston suggested to write, *e.g.*, A^{40} for the argon of mass 40; but this is hardly an acceptable suggestion.

In this discussion the physicists had it, as Sir O. Lodge remarked, all their own way. Professor Eddington spoke of epoch-making researches. Sir E. Rutherford dwelt on the importance of the integer values for the structure of matter and suggested that the chlorine might not be the same all over the world; chemists did not trouble about isotopes, as they could not separate them. That no chemist objected is, however, hardly a sign that they all accept the fact, that all the atomic masses (referred to oxygen = 16) have been proved to be integers. Every revision of atomic weights alters the figures, but does not remove the decimals, and though Dr. Aston's recent photographs are far more distinct than they came out in our reproductions of earlier results, the lines, for which so high an accuracy is claimed, are bands, and frequently diffused bands. Professor Rankine asked whether the lines might not represent unstable compounds, sums of elementary masses. Dr. Aston replied that his lines showed the definite intensity relations which chemists would expect. Lines like CH, CH_2, HCl, etc., were distinguishable from elementary lines, and starting from oxygen or hydrogen he had never found the line 17·5 (half of chlorine, 35), which always appeared when chlorine was introduced.

(To be continued.)

LITERATURE.

Motor Lorry Design and Construction. By C. T. SCHAEFER. London: Crosby Lockwood and Son. [Price 18*s.* net.]

DURING the war a very large number of American lorries were used in the English Army, and they proved, on the whole, most successful. In fact for the rough test which the war provided they proved in some cases to have very distinct advantages over the average English vehicle. Up to the outbreak of the war we had heard a good deal about American cars of the cheaper kind, which were establishing an increasing market in this country, but it was generally considered that this market depended entirely on their cheapness, and very few people thought that in a test such as the heavy lorry was put to in the war, the American vehicle would have any chance of competing with the British. Yet quite apart from the question of price, the American vehicle proved at least equal to the British one. A book on American commercial vehicle practice, therefore, is very welcome, and is well worth studying, for it may be taken for granted that the American manufacturer will not be content simply to keep his vehicles at the standard which proved successful in the war, but will rapidly improve them and eliminate those weak points which the war brought out.

The book under review consists of a little over 300 pages with just under 300 illustrations, and gives an excellent *resume* of American practice. The heavier type of commercial vehicle is mainly dealt with, but there is also a good deal of information as to the lighter machine carrying, say, a ton. The greater part of the book is occupied with the construction of the chassis, and the engine is only very lightly touched on. This seems a pity, as further information as to the engines would make the book very much more complete, or, on the other hand, it might have been better to omit the meagre description of the engine altogether, and add still further to the excellent information given as to the chassis and the various details of the parts which compose it. The same remark applies to the description of ignition apparatus. Nearly 30 pages are devoted to this. Modern magnetos are the production of specialists, and are practically never made by the people who construct the vehicle, and are seldom repaired by the user. Books have been written dealing exclusively with them, and it again appears that the space devoted to this branch would have been better spent in further details as to the chassis itself, or the engine which drives it.

In these days when there is a great agitation for the left-hand drive to be made illegal in this country, it is interesting to study the author's remarks on right and left-hand drive in America. As their rule of the road is the opposite to ours, right-hand drive there has the same disadvantages as left-hand drive has here. Yet a very large number of vehicles have been made, both in America and France with right-hand drive and the author, after reviewing the various arguments, considers that there is very little to choose between them, the advantage, apparently, being, in his opinion, slightly with the right-hand drive.

Another interesting point is the general use in America of sealed governors on the engines. This matter of governing seems quite an important one as there is no doubt as to the destruction of both vehicles and roads from too high a speed. The difficulty is that an engine governor which limits the speed to a reasonable one on the top gear on the flat, limits the speed too much on hills when the lower gears are in action. The result is that here governors are little in use, for if provided by the manufacturer they are generally disconnected by the user. In America, however, a combination governor is being experimented with. This is driven both by the engine and road wheels, so that there is a limit of engine speed when the lower gears are in use, and a limit of road speed on the top gear. Altogether the volume under notice contains a great deal of interesting information, and its value is increased by the large number of excellent illustrations.

Notes on Chemical Research. By W. P. DREAPER, O.B.E., F.I.C. Second edition. Text-books of Chemical Research and Engineering. London: J. and A. Churchill. [Price 7*s.* 6*d.* net.]

SCIENTIFIC books may be written as text books to serve as guides for systematic study, as reference volumes for ready consultation, or as essays. In this third case they will be perused after the manner of serious novels which are put down to be picked up again for meditation, or to be shelved. Much will depend upon the originality of the arguments and upon the style. It would be unfair to demand conspicuous originality and classical style in a brief discussion of Chemical Research, (I) Nature of Scientific Knowledge, Observation and Experiment, Selection of Subject-Matter, Methods of Investigation, Philosophy and Experimental Science, Chemical Research and Industry, and (II) Aims of Practical Science, Personal Factor, Laboratory Research and Works Practice, Efficiency, Large-Scale Operations, and the Student and his Course of Training—subjects on which the public has more been lectured during the past few years than during many preceding decades. Mr. Dreaper's arguments are to the point. But one cannot help feeling that he is sometimes a little prosy, and that the distinction of his two parts, as indicated (I) Scientific Fact and Method, and (II) Practical Research, is more distinct in the Table of Contents than in the text.

We read "that knowledge is either generalised or empirical. In the latter case it has not yet been expressed in terms which can be recognised, or referred to any known cause or law. Facts of this nature are considered useless for the purpose of science, although they may have a definite value in the arts and manufacture." When Mr. Dreaper says that "Science is concerned with the question how things take place; it has never, in a single case, been able to explain why," we concur. But we should hardly call "the difference between the how and the why of things apparently fundamental." Mr. Dreaper is doubtful whether the terms "pure" and "applied" research still serve a useful purpose, and he suggests to replace the terms by "static" and "dynamic"; why these latter terms, he does not explain. We hardly follow his comments on the Nature of Discovery. Later on he heads his chapter on Methods of Investigation by a quotation from Gore: "No scientific discovery can with any justice be considered as due to accident." That dictum can be accepted only if we take "scientific" as implying systematic study, and one of Mr. Dreaper's other mottoes ascribed to Marshal Foch: "Nothing exists except facts, and acts alone are of any consequence," cannot be accepted in any sense; this motto is placed over the chapter on Laboratory Research and Works Practice. We do not understand either why Mr. Dreaper should endorse Sir William Osler's advice to his medical students, "Take no thought for the morrow. Live neither in the past, nor in the future, but let each day's work absorb your entire energy." But he gives good advice as to methods of recording results and the necessity of keeping careful notes, which would save many of us days wasted on hunting up references and rediscovering what we ourselves had found out long ago, and in many other matters. He deprecates the waiting policy of British manufacturers who prefer to have research problems worked out elsewhere, and he is probably wise in doubting the general necessity of post-graduate research. As we have referred to Mr. Dreaper's mottoes, we might finally say a word upon one of his best and most appropriate, due to Pasteur: "Science and the applications of science are united together as the tree and the fruit." People are very ready to nurse the fruit, when and as it appears, and to pick it and dispose of it to advantage. They do not see why they should be bothered with the gardener's care of the soil, the seed, and the young tree, which after all may not bear any fruit; and yet they grumble about futile research.

BOOKS RECEIVED.

United States Bureau of Mines. Bulletin No. 196. *Coal-Mine Fatalities in the United States, 1919. List of Permissible Explosives, Lamps and Motors Tested prior to January* 31, 1920. By ALBERT H. FAY. [Price 15 cents.] Technical Papers. No. 235. *Safe Storage of Coal.* By H. H. STOCK. [Price 5 cents.] No. 243. *Development of Liquid Oxygen Explosives during the War.* By GEORGE S. RICE. [Price 10 cents.] No. 245. *Quarry Accidents in the United States. During the Calendar Year* 1918. By ALBERT H. FAY. [Price 10 cents.] No. 247. *Perforated Casing and Screen Pipe in Oil Wells.* By E. W. WAGG. [Price 20 cents.] No. 253. *Effects of Gasoline Removal on the Heating Value of Natural Gas.* By DONALD B. DOW. [Price 5 cents.] Washington: Government Printing Office.

Fourth Annual Report of the National Advisory Committee for Aeronautics, 1918. Washington: Government Printing Office.

Principles of Reinforced Concrete Construction. By F. E. TURNEAURE and E. R. MAURER. Third edition, revised and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 21*s.* net.]

Structural Drafting and the Design of Details. By CARLTON THOMAS BISHOP, C.E. First edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 27*s.* 6*d.* net.]

The Book of the Ford. By R. T. NICHOLSON, M.A., Fifth edition. London: Temple Press, Limited. [Price 3*s.* net.]

Governors and the Governing of Prime Movers. By W. TRINKS, M.E. London: Constable and Co., Limited. [Price 22*s.* 6*d.* net.]

Geodesy, including Astronomical Observations, Gravity Measurements and Method of Least Squares. By GEO. L. HOSMER. First edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18*s.* 6*d.* net.]

Prospecting for Oil and Gas.—By L. S. PAMGITY. First edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18*s.* net.]

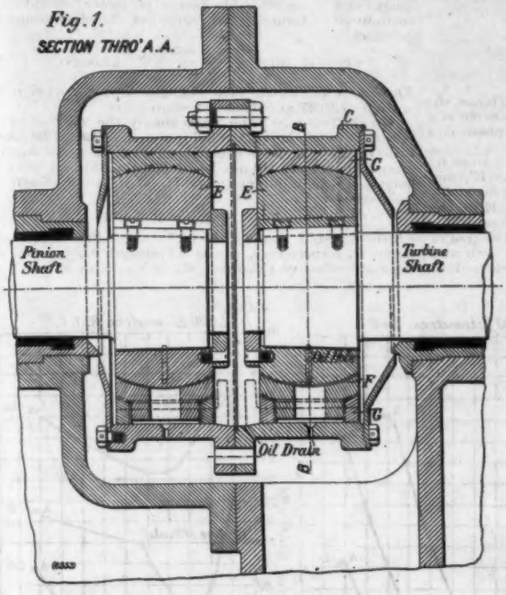
The 100 *Best Investments. Tenth Annual Volume.* London: British, Foreign and Colonial Corporation, Limited. [Price 2*s.* net.]

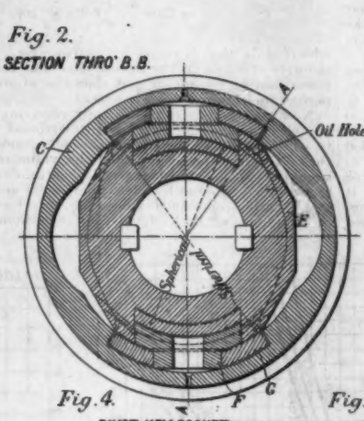
Annuario de Mineria, Metalurgia, Electricidad y Demas Industrias de España. Ano 1920. Bajo la Direccion de Don ADRIANO CONTRERAS, DON ROMAN ORIOL y Don LUIS ORIOL. Madrid: Sucesores de Rivadeneyra (S.A.). Pasco de San Vicente 20. [Price 8·50 pesetas.]

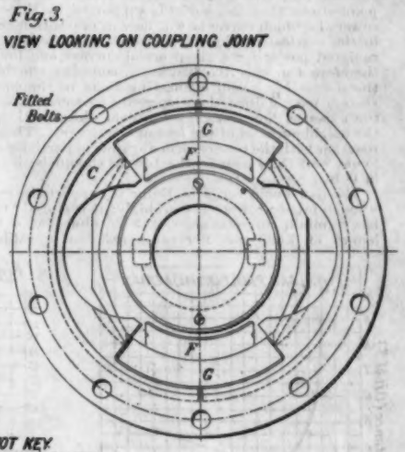
The Engineering Enquiry. A New Pocket Book for Engineers. For the Practical Assistance of Agents, Contractors, Engineers, Estimating, Commercial and Technical Correspondents, Merchants, Representative and Salesmen. By TOMEY THOMPSON. Bristol: J. W. Arrowsmith, Limited; London: Simpkin, Marshall, Hamilton, Kent and Co., Limited. [Price 7*s.* 6*d.*]

FUEL SAVING IN FRANCE.—We read in *L'Electricien*, Paris, that following upon a vote of the Paris Municipality, the Prefect of the Seine Department has opened a competition, for which 100,000 francs have been set apart for distribution in prizes, with a view to arriving at practical means for attenuating the fuel crisis. The competition is to bear on the apparatus, products, or processes which can come into use either from the commencement of next winter or at a later date. When the competitors have been classified by the deciding jury, an exhibition is to be held at the end of October of the schemes which are likely to give immediate results; those which require a longer *étude* will be exhibited in April to May, 1921. Further particulars may be obtained by addressing the Préfecture de la Seine, Office des Charbons, 4, Rue Lobau, Paris.

THE "ROBERTSON-FAIRFIELD" FLEXIBLE EXPANSION COUPLING.







THE "Robertson-Fairfield" coupling, which we illustrate on this page, was designed primarily for use with geared turbines installed on shipboard. The lack of rigidity in the ship's structure makes it very difficult to maintain accurate alignment between the axis of a pinion and the axis of the turbine rotor which drives it. It is thus desirable to provide not only for relative motion axially between the two shafts, but also for a change in the angle between them. The coupling should, in other words, be not only an expansion coupling, but a flexible coupling. Most types hitherto in use, though bearing the latter designation, are mis-named, being really merely expansion couplings. As shown in Figs. 1 to 3, above, the "Robertson-Fairfield" coupling consists of a casing or shell, C, made in halves, which are bolted together when the coupling is assembled. The inner surface of this shell has two gaps or slots machined in it, and in these gaps are fitted the blocks, G, which have been named by the designers "pivot key sockets," one of which is represented separately in Fig. 4. These "pivot key sockets" transmit the drive to the casing by coming into contact with the ends of their slots, whilst at the same time, any relative axial motion between the drivers and the driving shaft is provided for by the sliding of these blocks along their slots in the shell, C. The drive of the turbine shaft is transmitted to the two pivot key sockets, G, shown on the right of Fig. 1, by means of pivot keys, F, of which one is shown separately in Fig. 5, whilst others can be seen in place in Figs. 1, 2 and 3. A pin or boss turned on the convex face of these pivot keys fits into a corresponding hole in the "pivot key sockets," as is best seen in Figs. 1 and 2. The abutting surfaces of the pivot keys and the pivot key sockets are spherical, as is also the inner face of each pivot key. Each pivot key fits into a slot cut in a block, E, secured to the end of the driving or the driven shaft. These slots are machined to fit the spherical face of the inner surfaces of the pivot keys. These keys, therefore, can slide over their seats should the coupled shafts get out of alignment, whilst an angular displacement at right angles to that thus secured, is provided for by a slight rotation of the pivot key sockets on their pins. As shown in Fig. 1, the coupling is lubricated by the oil which flows from the adjacent bearings. The oil is caught by the end-plates shown in Fig. 1, and, after passing between the moving surfaces of the coupling, escapes through small drain holes shown in Fig. 1. The coupling runs drowned in oil, and gutters are machined in the internal parts of the coupling to ensure a thorough distribution of the lubricant. The upper half of Fig. 1, it may be observed, is a bastard section taken along the radius lettered A in Fig. 2. The pressures on the bearing surface are quite definite, bearing free from the indeterminateness which exists in the case of multiple claw-couplings, as a consequence somewhat higher bearing pressures are permissible, the figures adjusted being from 500 lb. to 750 lb. per sq. in.

The manufacture of the coupling consists almost entirely of machining operations, very little hand fitting being required. It is already being applied to geared marine turbines aggregating over 300,000 shaft horse-power. The working of the patent has been taken over by Michell Bearings, Limited, of 3, Central Buildings, London, S.W. 1.

THE EFFICIENCY OF AERIALS AND THE POWER REQUIRED FOR LONG-DISTANCE TRANSMISSION.*

By Professor G. W. O. HOWE, D.Sc.

OF the total power supplied to the aerial of a transmitting station a portion is dissipated in the resistance of the wires constituting the aerial, tuning coils, secondary winding of the oscillation transformer, and earth or counterpoise wires, a portion is dissipated in imperfect dielectrics situated in the electric field, such as wooden masts, buildings, soil, &c., and a portion is radiated. If R be the total effective resistance of the aerial and I the root-mean-square current, we may write

$$I^2 R = I^2 (R_w + R_d + R_r)$$

where the suffixes, w, d, and r refer to wires, dielectrics and radiation, respectively. Of the three terms the first can be calculated with considerable accuracy and can be kept small by suitable design, the third can also be calculated with some degree of confidence, but it is very difficult to form even a rough estimate of the second term.

The power radiated from an antenna of height h at a wavelength λ is equal to $1584\,(h/\lambda)^2\,I^2$ watts on the assumptions that the upper capacity is so large that the current has the same value at every point of the vertical wire and that the height is small compared with the wavelength. The latter assumption is usually justified, and any doubt as to the former is removed by taking h to be the effective height, which is less than the actual height by an amount which can be calculated approximately in many cases. The radiation resistance R is therefore equal to $1584\,(h/\lambda)^2$ and is inversely proportional to the square of the wavelength. With regard to the dielectric losses it is known that the power-factor of a condenser, *i.e.*, the ratio of the power dissipated to the product of current and voltage is approximately independent of the frequency. Hence $I^2 R_d$ bears a fixed ratio to I V where V is the voltage to which the aerial is charged, or, since $I = \omega V C$ and $I V = I^2/(\omega C)$, R_d must bear a fixed ratio to $1/(\omega C)$ and $\omega C R_d$ must be constant. R_d is therefore inversely proportional to the frequency or directly proportional to the wavelength. Now not only can R_w be made small but it is less dependent on the frequency than either R_r or R_d. If the wavelength is increased by inserting additional turns in the inductance, the conductor resistance would thereby tend to increase, but this would be counteracted to some extent, if not entirely, by reduced skin-effect. As an approximation R_w may therefore be regarded as constant, and the equation $R = R_w + R_d + R_r$ may be written

$$R = a + b\lambda + \frac{c}{\lambda^2}$$

where a, b, and c are constants.

$$\frac{d R}{d \lambda} = b - \frac{2c}{\lambda^3}$$

If R be plotted against λ, the slope of the curve will therefore be negative for values of λ less than $\sqrt[3]{(2c/b)}$, but positive for higher values of λ. The total effective resistance is a minimum for that value of λ which is equal to $\sqrt[3]{(2c/b)}$. Calling this value of the wavelength λ_m, we have

$$\lambda_m = \sqrt[3]{\frac{2c}{b}}$$

and for the value of the total effective resistance at this wavelength we have

$$R_m = a + b\lambda_m + \frac{c}{\lambda_m^2}$$
$$= a + \frac{2c}{\lambda_m^3}.\lambda_m + \frac{c}{\lambda_m^2}$$
$$= a + \frac{3c}{\lambda_m^2} = a + 3R_{rm}$$

where R_{rm} is the radiation resistance at the wavelength λ_m.

The total resistance is a minimum for that wavelength at which the dielectric losses are twice the radiated power. From the observed values of R at three different wavelengths it should be possible to calculate the three constants a, b, and c, and thus determine the three component resistances, but the measurements would have to be made with special care to give accurate values. If it be assumed that R_w is negligibly small, then at the wavelength λ_m, the radiation resistance is a third of the measured total resistance, and therefore

$$\frac{R_m}{3} = 1584\,\frac{h^2}{\lambda_m^2}$$

from which the effective height can be calculated.

In the Bulletin of the Bureau of Standards* L. W. Austin has given curves showing the measured effective resistances of a number of aerials at various frequencies. Although the data given are rather scanty, we have applied the above formula to each case with the results shown in Table I.

TABLE I.

Aerial.	Length Metres.	Capacity 10^{-3} Farads.	Height. Metres.	λ_m.	R_m.	Effective Height.
Bureau of Standards, harp ..	42·6	1·26	54·8	700	11·5	34·3
Signal corps, flat top	44·5	1·71	39·6	1,300	6·7	48·5
Capitol, flat top ..	85·0	2·32	44·2	1,000	7·0	38·0
Navy yard, harp..	51·8	0·73	54·8	900	5·0	29·4
U.S.S. Maine, flat top	32·9	1·25	38·4	800	2·25	17·4
U.S.S. Massachusetts, flat top ..	24·4	1·10	39·0	1,000	2·75	24·1
Arlington, sloping top	—	9·4	137 to 188	7,000	1·1	107·0

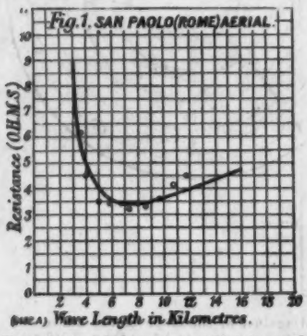
The last column gives the effective heights calculated in this way on the assumption that the wire resistance R_w is negligible; it is certainly not negligible but in the absence of further data it can only be said that the

* Paper read before Section G of the British Association at their meeting at Cardiff, August 27, 1920.

* Bulletin of the Bureau of Standards, 9, pages 65—72, 1913.

actual values of the effective heights must be less than these calculated values, and in some cases probably very much less. It has been stated that the Arlington antenna has an effective height of 137 metres, but how this was determined we do not know; the above calculation indicates a much smaller value. It should be pointed out that this aerial is supported by three steel towers in which currents will flow in opposition to that in the vertical portion of the aerial, thus reducing the radiated power for a given aerial current and lowering therefore the effective height. Insulating the feet of the towers instead of connecting them to the earthing system may reduce these currents to some extent, at the expense, however, of additional dielectric losses in the neighbourhood of the feet of the towers. The aerial together with the towers form a system of partially closed loops, and the losses in the towers should be included in $I^2 R_w$.

The San Paolo aerial at Rome is supported by three wooden lattice towers 218 m. high; it is stated* that it has a minimum resistance of 3·25 ohms. at a wavelength of 7,000 m. Reception tests on a calibrated



The points marked are measured values. The curve is plotted from the equation $R = 0{\cdot}5 + 0{\cdot}26\lambda + 54{\cdot}3/\lambda^2$.

frame aerial indicate an effective height of 138 m. Neglecting R_w the above formula gives an effective height of 183 m.; to obtain 138 m., one must assume the conductor resistance R_w to be 1·4 ohms. This is an improbably high value of R_w and tends to confirm the doubt expressed in the paper referred to as to the accuracy of the measured resistances with undamped waves. Fig. 1 shows the measured effective resistance of the San Paolo aerial at various wavelengths. The curve is plotted from values calculated from the formula $R = 0{\cdot}5 + 0{\cdot}26\lambda + 54{\cdot}3/\lambda^2$. This formula gives the minimum resistance at a wavelength of 7·5 km.

It is evidently desirable that very accurate measurements should be made of the total effective resistance at various wavelengths of different types of aerials making allowance for the high-frequency resistance of the aerial, tuning coils, and earth wires, or counterpoise. By making such measurements on aerials with steel masts and wooden masts, with earthing wires and insulated counterpoises, much valuable information would be gained as to the magnitude of the losses and as to the use or misuse of every kilowatt generated. With the limitations at present imposed by the stage of development reached in the construction of large thermionic valves, the last-named consideration is one of the greatest importance.

Assuming the aerial to have a large upper capacity and to be radiating at a wavelength very large compared with the height, we have for the radiated power

$$P_{rad} = 1{\cdot}584\,\frac{h^2}{\lambda^2}\,I^2 \text{ kilowatts}$$

* *Proceedings of the Institute of Radio Engineers*, 8, p. 142, April 1920. Radio Review Abstract, No. 538, July 1920.

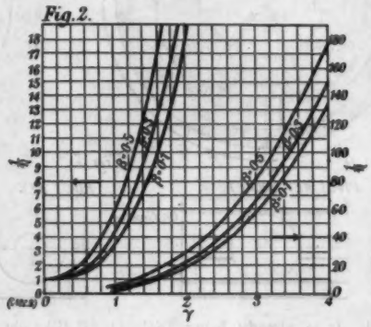
where I is the root-mean-square current in amperes. The electric field strength at a distant point of the earth's surface is given by the formula

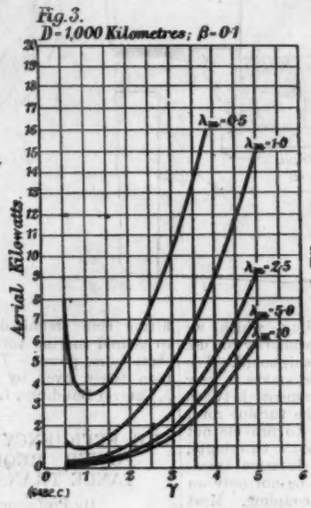
$$E = \frac{4\pi}{10}\cdot\frac{h}{\lambda}\cdot\frac{I}{d} \text{ e.s. units.}$$

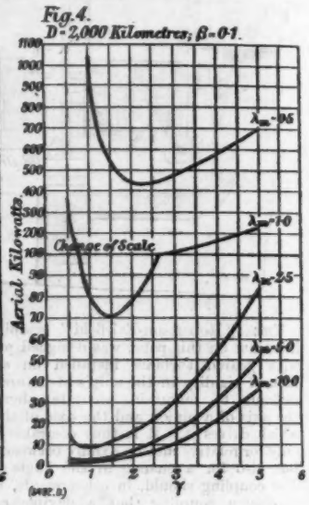
$$= 120\pi\,\frac{h}{\lambda}\cdot\frac{I}{d} \text{ volts per cm.}$$

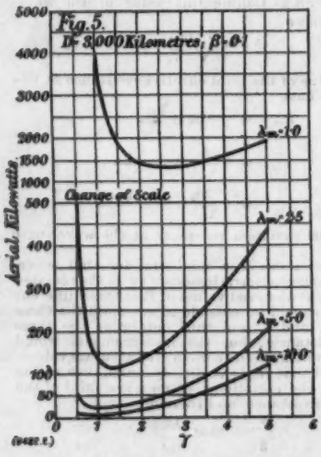
where d is the distance in centimetres. This is the theoretical value on the assumption that the earth is a plane perfect conductor and that the atmosphere is a perfect dielectric of infinite extent.

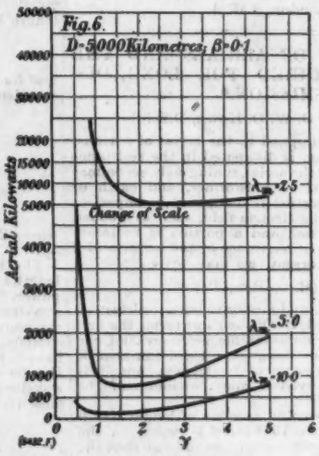
Now the power supplied to any receiving station by the electromagnetic waves is proportional to E^2, and to be able to read the signals through atmospheric disturbances it is necessary that the value of E at the receiving station should exceed a certain value. This is not much affected by the size of aerial and degree of amplification employed since these factors influence the loudness of both signals and atmospheric noises.

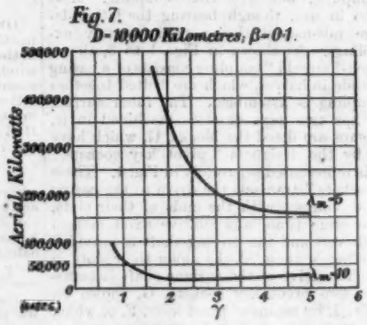












We are neglecting here any secondary differences due to directive effects, &c.

Putting D for the distance in kilometres, we have

$$E^2 = \frac{14400\,.\,\pi^2}{10^{10}}\cdot\frac{h^2}{\lambda^2}\cdot\frac{I^2}{D^2} \quad (E = \text{volts per cm.})$$

and therefore

$$\frac{P_{rad}}{E^2} = \frac{1{\cdot}584\,.\,10^{10}}{14400\,.\,\pi^2}\,.\,D^2 \left(\frac{\text{kilowatts}}{(\text{volts per cm.})^2}\right)$$

$$= 1{\cdot}11\,.\,10^5\,.\,D^2$$

If P is the total power supplied to the transmitting aerial, the ratio of P_{rad} to P may be called the efficiency of the aerial and we may write

$$\frac{P_{rad}}{P} = \eta$$

We shall assume that the theoretical formula just established is brought into agreement with experimental results by the introduction of the Austin-Cohen exponential factor. The formula then becomes

$$\frac{P}{E^2} = 1{\cdot}11\,.\,10^5\,.\,\frac{D^2}{\eta}\,.\,e^{0{\cdot}003\,D/\sqrt{\lambda}}$$

where D and λ are both in kilometres.

L. W. Austin found that to give readable signals at Brant Rock when receiving from U.S. cruisers, it was necessary to have a received current of 40 microamperes set up in the antenna which had a total effective resistance of 25 ohms and an effective height of about 200 ft. To produce a current of $40\,.\,10^{-6}$ amperes in 25 ohms requires an electromotive force of 0·001 volt, which divided by the effective height of the aerial gives a field strength of $1{\cdot}64\,.\,10^{-7}$ volts per centimetre.

Inserting this value of E in the above formula we get

$$P = 3\,.\,10^{-9}\,.\,\frac{D^2}{\eta}\,.\,e^{0{\cdot}003\,D/\sqrt{\lambda}} \text{ kilowatts.}$$

To ensure a reliable commercial service under all conditions a considerable factor of safety should be introduced. Assuming a factor of 5, the formula becomes

$$P = 15\,.\,10^{-9}\,.\,\frac{D^2}{\eta}\,.\,e^{0{\cdot}003\,D/\sqrt{\lambda}} \text{ kilowatts.}$$

This gives an electric field strength E at the receiving station of 0·37 microvolt per centimetre.

We shall now consider more closely the value of the efficiency η of the transmitting aerial. Let β be the ratio of the conductor resistance R_w of the aerial earth system, which we assume to be constant for all wavelengths, to the minimum value R_m of the total effective resistance; then

$$R_w = \beta\,R_m = \beta\,(R_w + R_{dm} + R_{rm})$$

where R_{dm} and R_{rm} are the dielectric and radiation resistances, respectively, at the wavelength λ_m for which the total effective resistance R_m is a minimum.

Since, at this wavelength, $R_{dm} = 2\,R_{rm}$, we have

$$R_m = \beta\,R_m + 3\,R_{rm}$$

and

$$R_{rm} = R_m\,.\,\frac{1-\beta}{3}$$

Since the dielectric resistance is directly proportional to λ, whilst the radiation resistance is inversely proportional to λ^2, we have

$$R = \beta\,R_m + 2\,\gamma\,R_{rm} + \frac{R_{rm}}{\gamma^2}$$

$$= R_m\left\{\beta + \frac{1-\beta}{3}\left(2\,\gamma + \frac{1}{\gamma^2}\right)\right\}$$

where

$$\frac{\lambda}{\lambda_m} = \gamma.$$

Of this total resistance R, the only useful part is that representing the radiation, viz.:—

$$R_r = \frac{R_{rm}}{\gamma^2} = R_m\,\frac{1-\beta}{3\,\gamma^2}$$

Hence

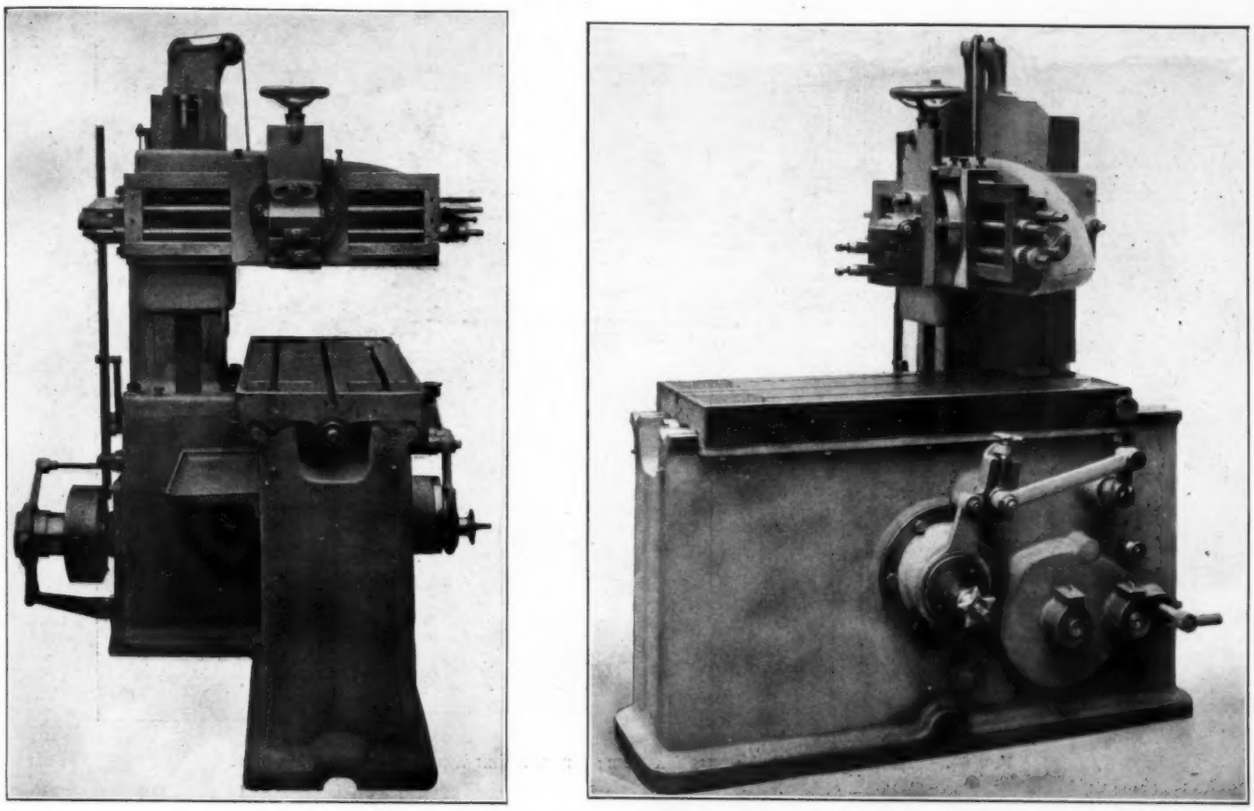
$$\frac{1}{\eta} = \frac{R}{R_r} = \frac{3\,\gamma^2\,\beta}{1-\beta} + 2\,\gamma^3 + 1$$

Table II opposite gives the calculated values of $1/\eta$ for various values of β and γ. These values are plotted in Fig. 2 for $\beta = 0{\cdot}1$, $0{\cdot}3$, and $0{\cdot}5$.

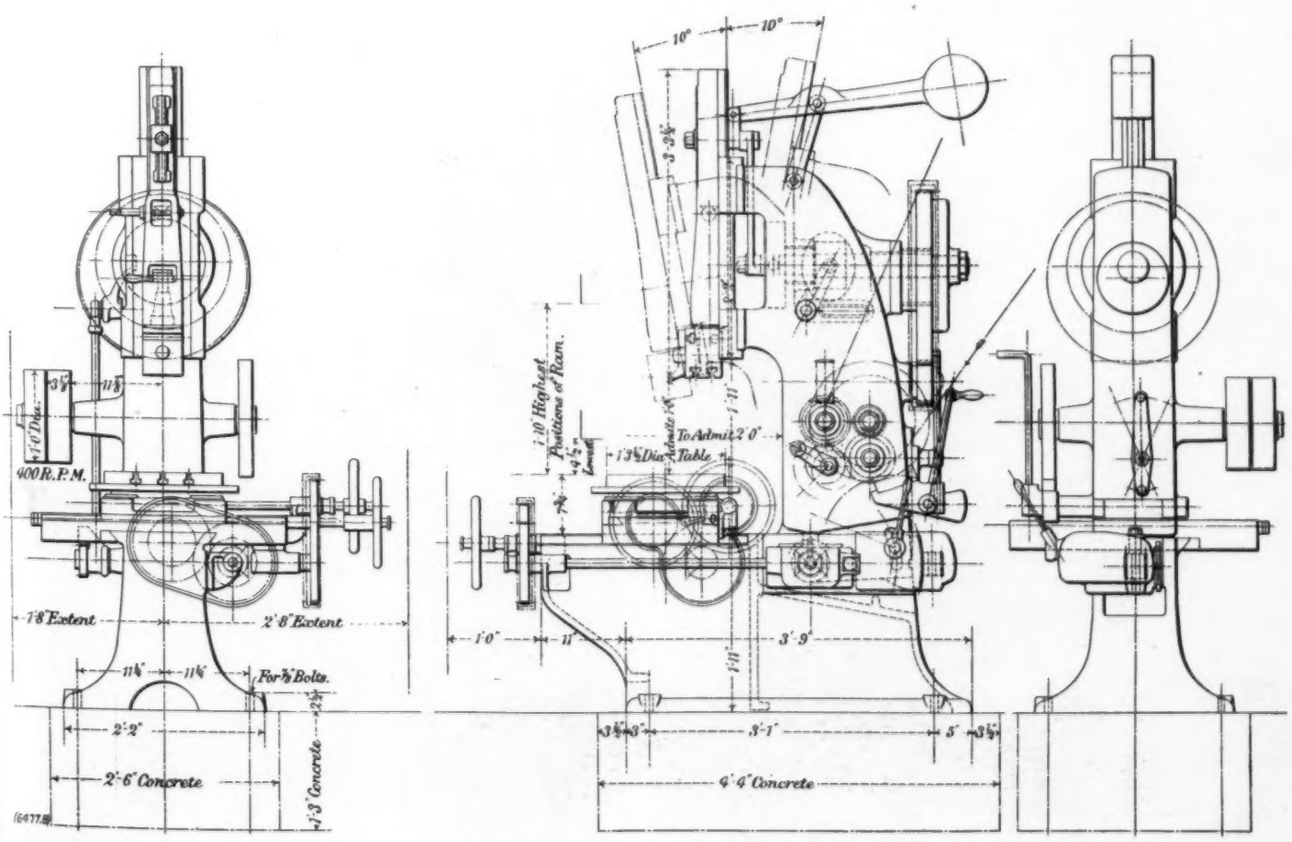
These figures are very striking; they show that if a warship with an aerial for which $\lambda_m = 1{,}000$ m. transmits at a wavelength of 3,000 m., less than 2 per cent. of the energy actually supplied to the aerial is radiated, the remaining 98 per cent. being dissipated in aerial losses, whereas at a wavelength of 1,000 m. 30 per cent. may be radiated.

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)



FIGS. 55 AND 56. 24-IN. OPENSIDE PLANING MACHINE; MESSRS. WARD, HAGGAS AND SMITH.



FIGS. 57, 58, AND 59. 6-8-IN. TILTING HEAD SLOTTER; MESSRS. THE BUTLER MACHINE TOOL COMPANY, LTD.

(*To face page* 334.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)

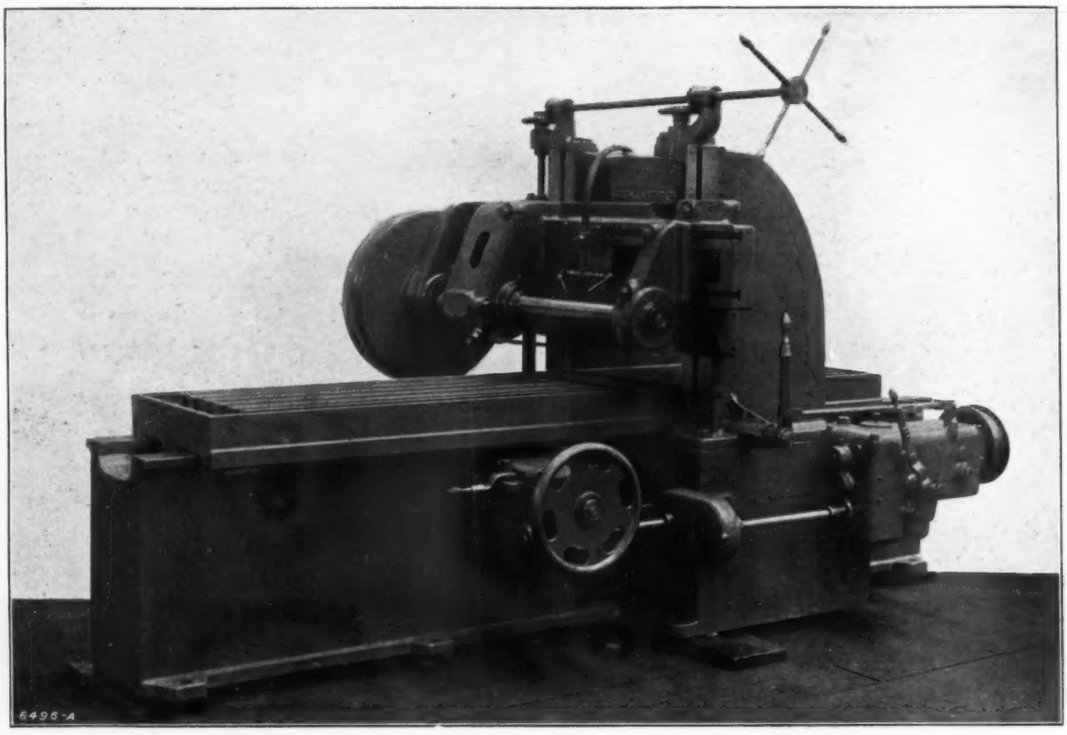


FIG. 60. HORIZONTAL PLANO-MILLING MACHINE; MESSRS. KENDALL AND GENT (1920), LTD.

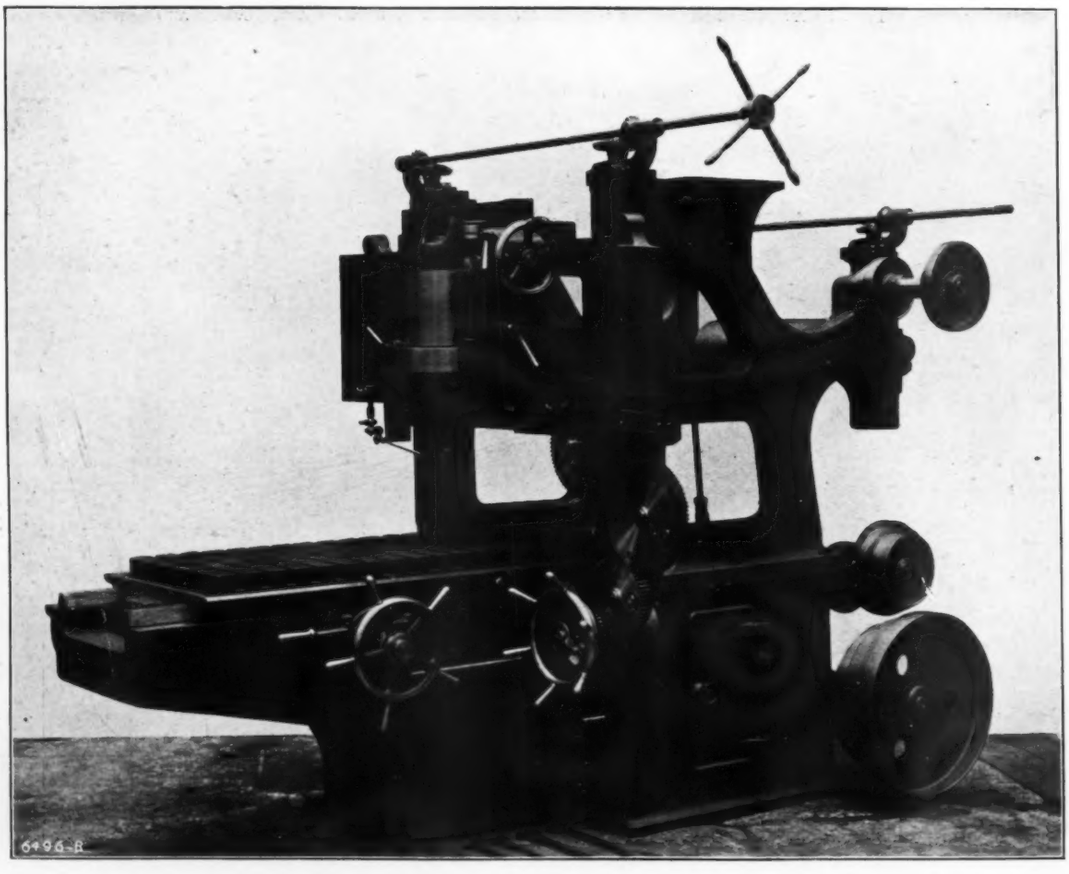


FIG. 61. VERTICAL PLANO-PROFILE MILLING MACHINE; MESSRS. KENDALL AND GENT (1920), LTD.

(*To face page* 335.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)

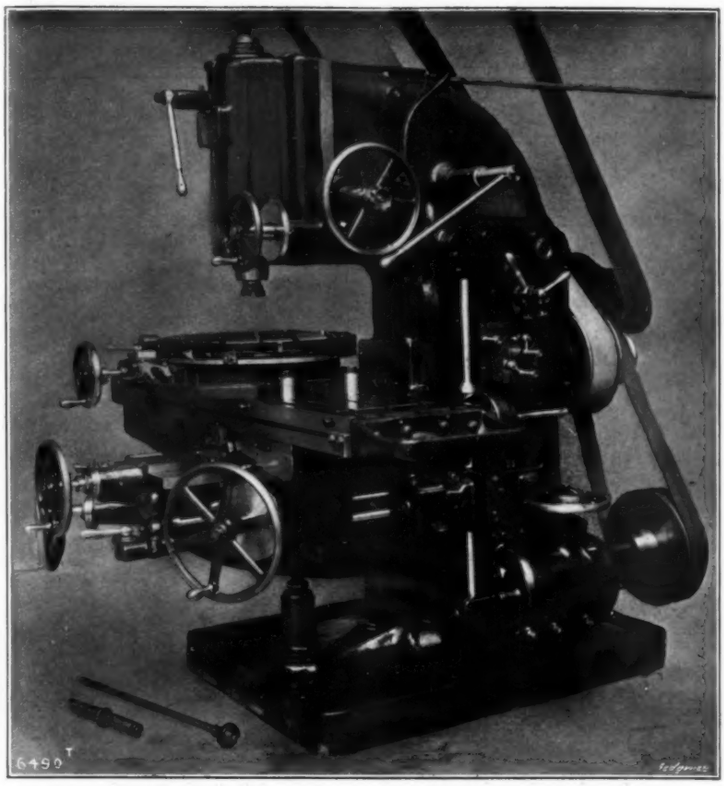


FIG. 63. VERTICAL MILLING MACHINE; MESSRS. ALFRED HERBERT, LTD.

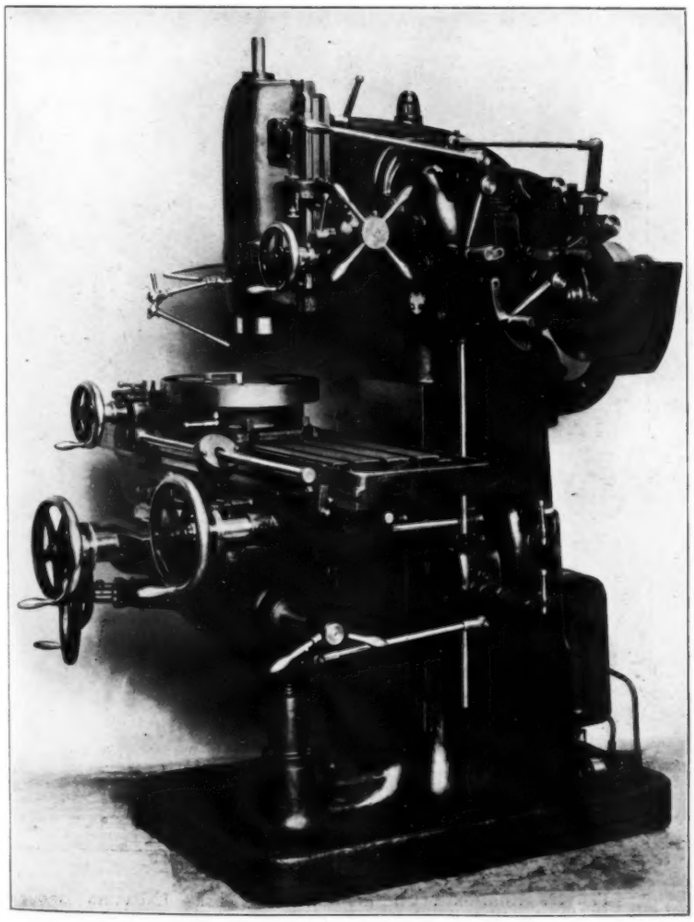


FIG. 64. VERTICAL MILLING MACHINE; MESSRS. JAMES ARCHDALE AND CO., LTD.

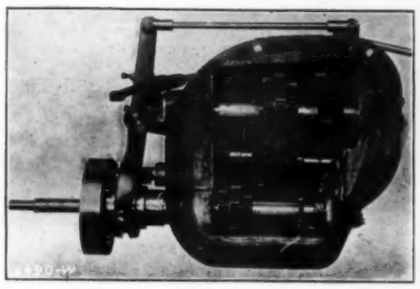


FIG. 65.

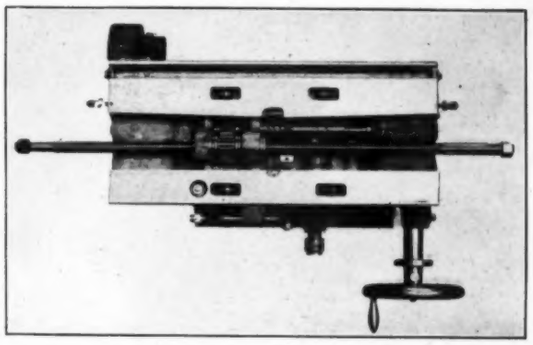


FIG. 66.

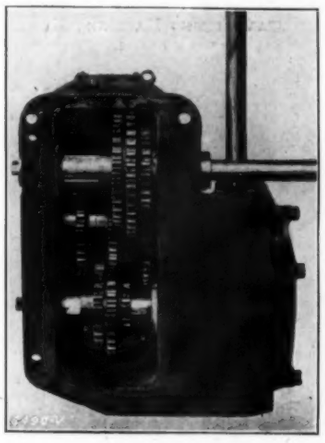


FIG. 67.

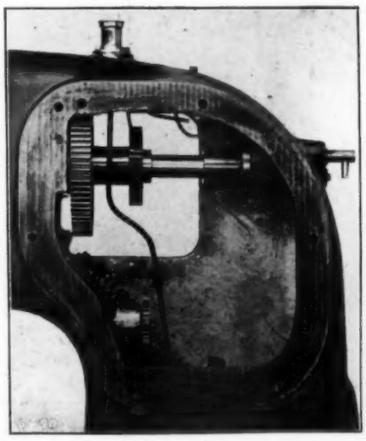


FIG. 68.

FIGS. 65 TO 68. DETAILS OF VERTICAL MILLING MACHINE; MESSRS. JAMES ARCHDALE AND CO., LTD.

(*To face page* 336.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description see Page* 333.)

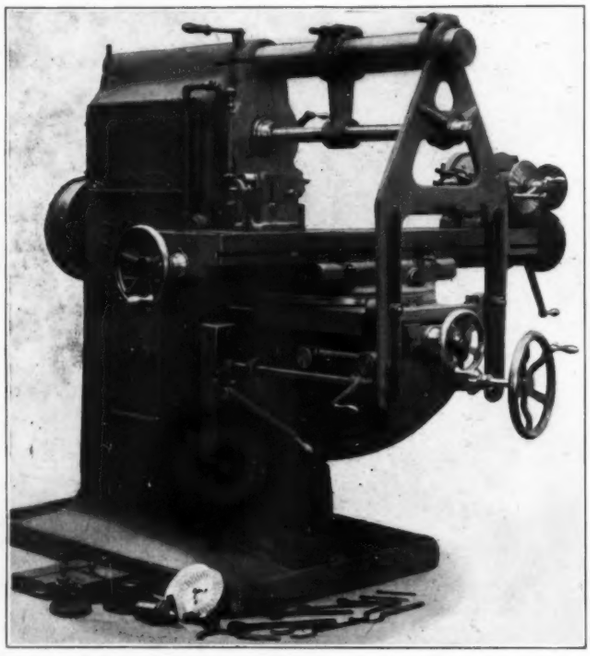


FIG. 69. HORIZONTAL MILLING MACHINE; MESSRS. CUNLIFFE AND CROOM, LTD.

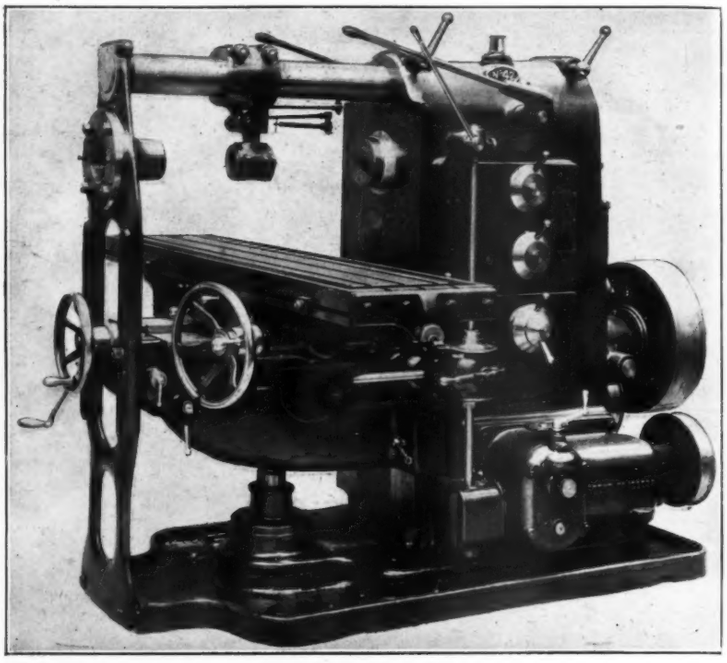


FIG. 70. HORIZONTAL MILLING MACHINE; MESSRS. SMITH AND COVENTRY, LTD.

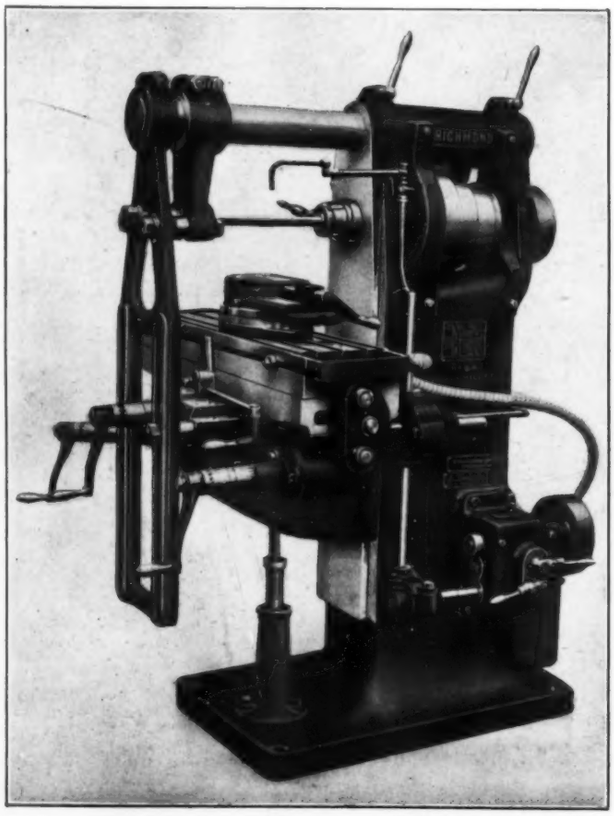


FIG. 71. HORIZONTAL MILLING MACHINE; MESSRS. MIDGLEY AND SUTCLIFFE.

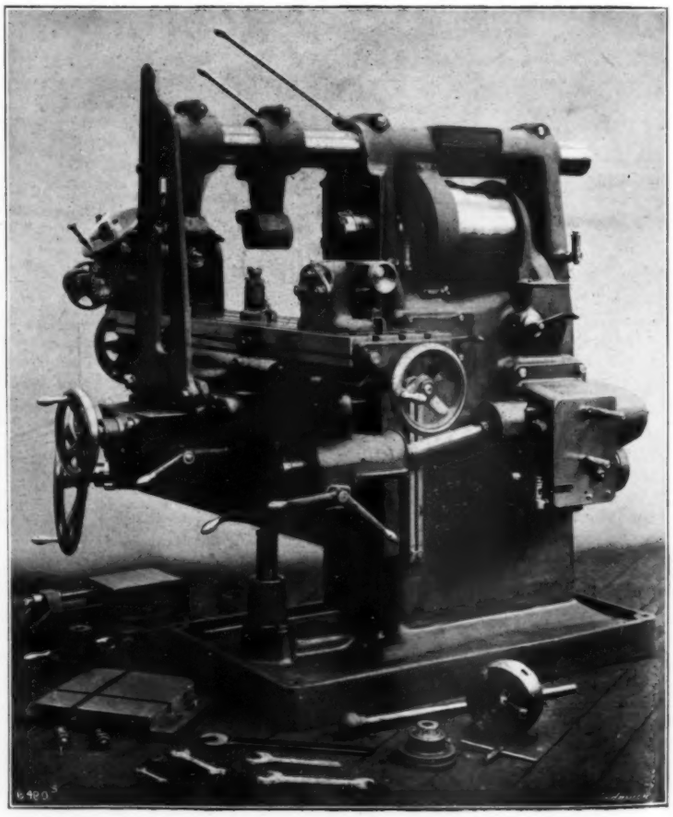


FIG. 72. HORIZONTAL MILLING MACHINE; MESSRS. J. PARKINSON AND SON.

(*To face page* 337.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)

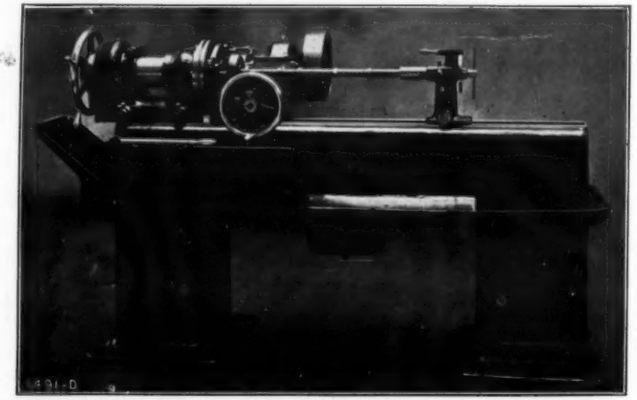


FIG. 73. CAM SHAFT MILLING MACHINE; MESSRS. WEBSTER AND BENNETT, LTD.

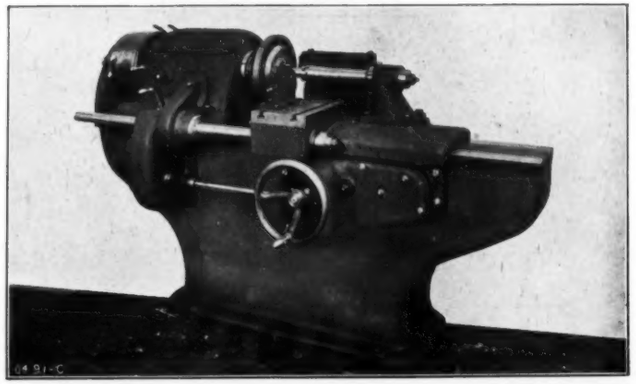


FIG. 74. PISTON RING AUTOMATIC LATHE; MESSRS. THOMAS RYDER AND SON, LTD.

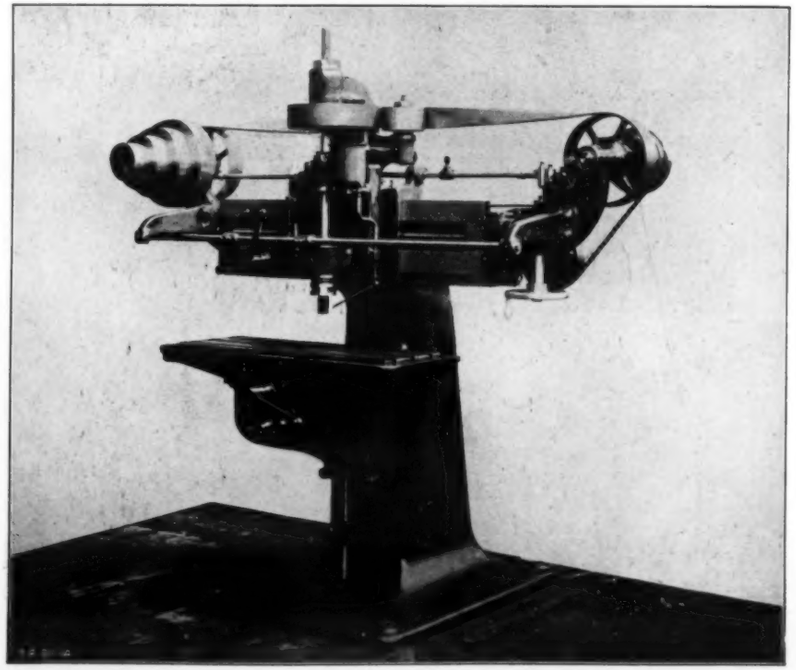


FIG. 75. KEY-SEATING AND SLOT-DRILLING MACHINE; MESSRS. GEORGE RICHARDS AND CO., LTD.

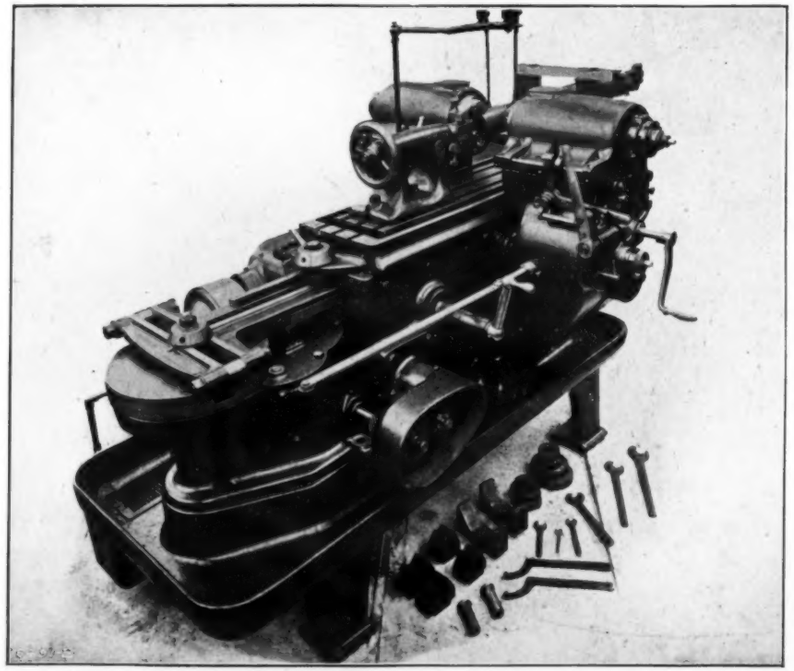


FIG. 76. KEY-SEATING AND MORTISING MACHINE; MESSRS. SMITH AND COVENTRY, LTD.

(*To face page* 338.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)

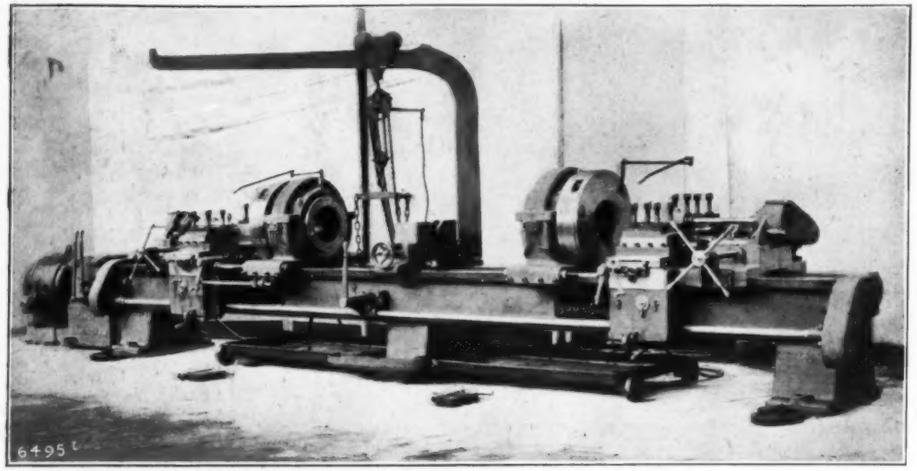


FIG. 77. AXLE CENTRING MACHINE; MESSRS. TANGYES, LTD.

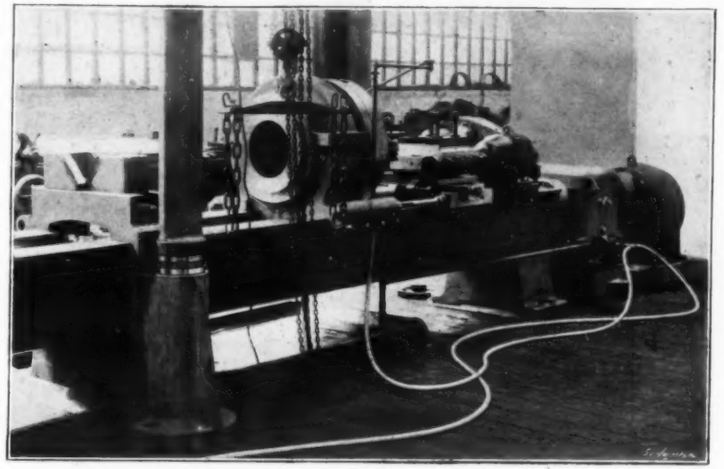
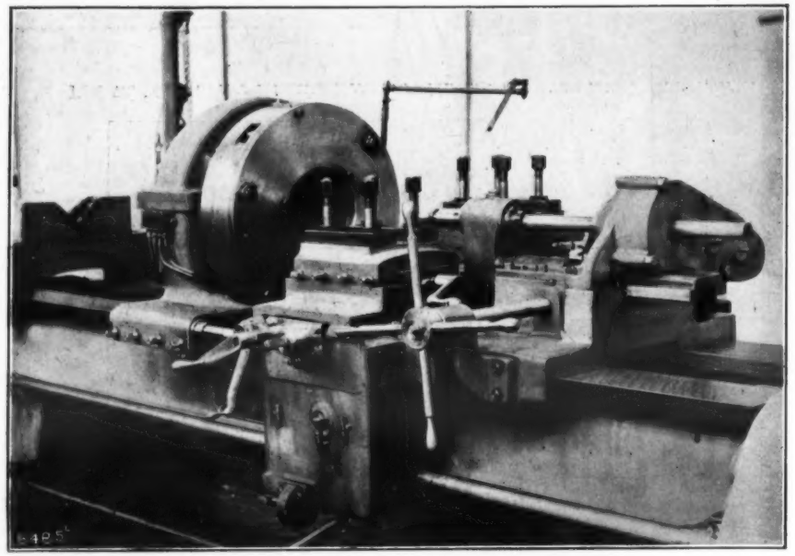
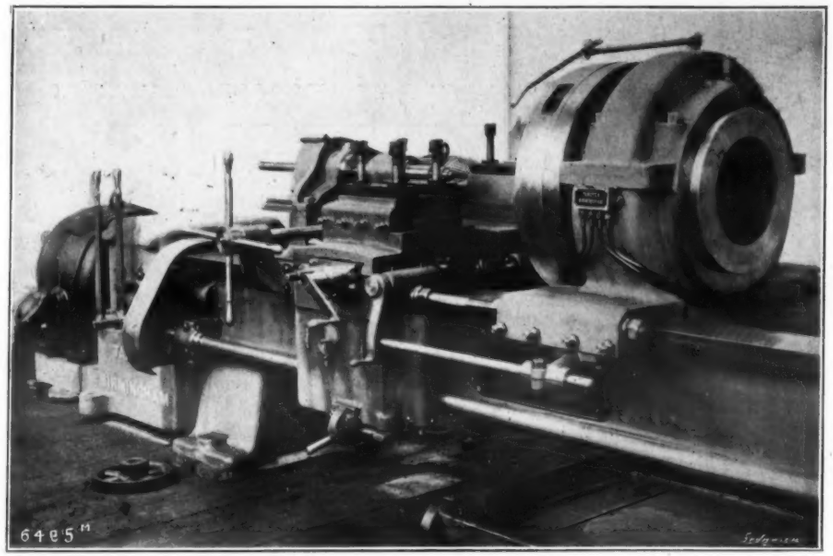


FIG. 78. BACK VIEW OF TANGYE AXLE CENTRING MACHINE.





FIGS. 79 AND 80. SADDLE, AND CENTRING DRILL OF TANGYE AXLE CENTRING MACHINE.

(*To face page* 339.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)

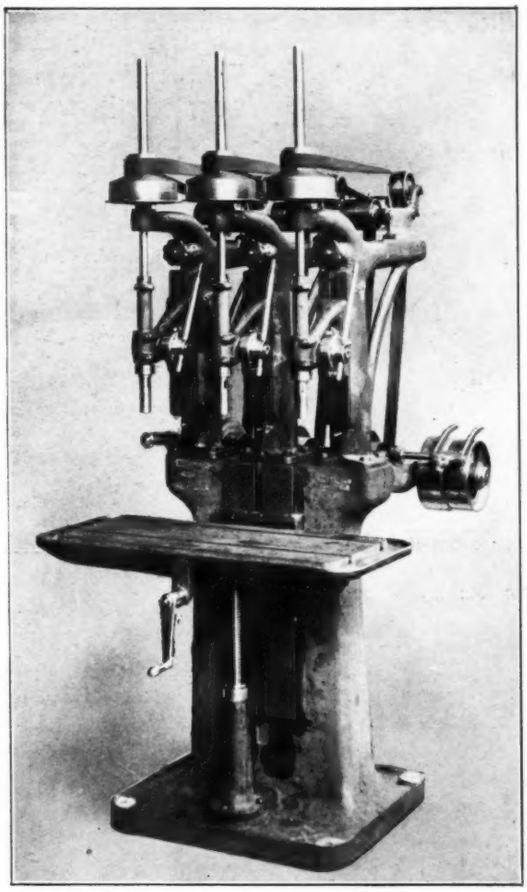


FIG. 91. THREE SPINDLE GEAR-DRIVEN SENSITIVE DRILL; MESSRS. FREDERICK POLLARD & CO., LTD.

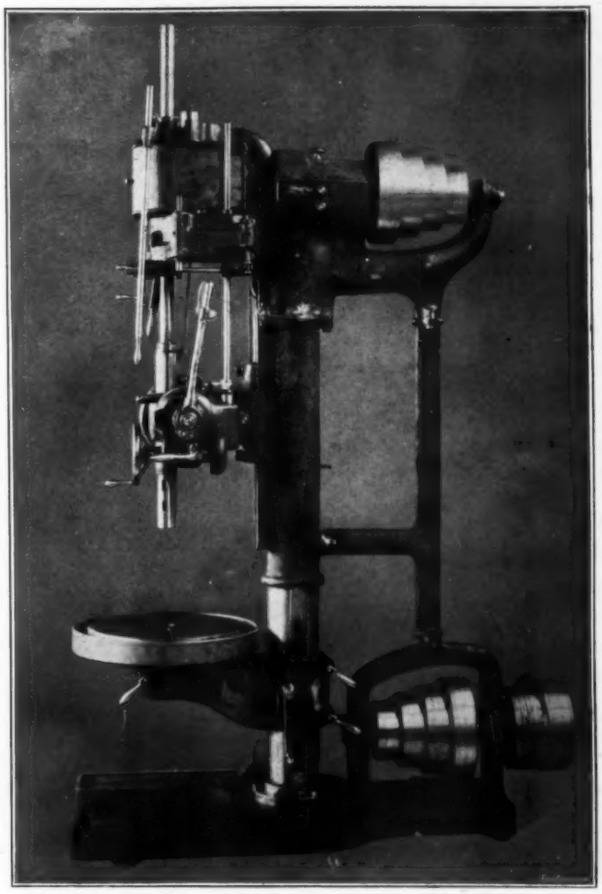
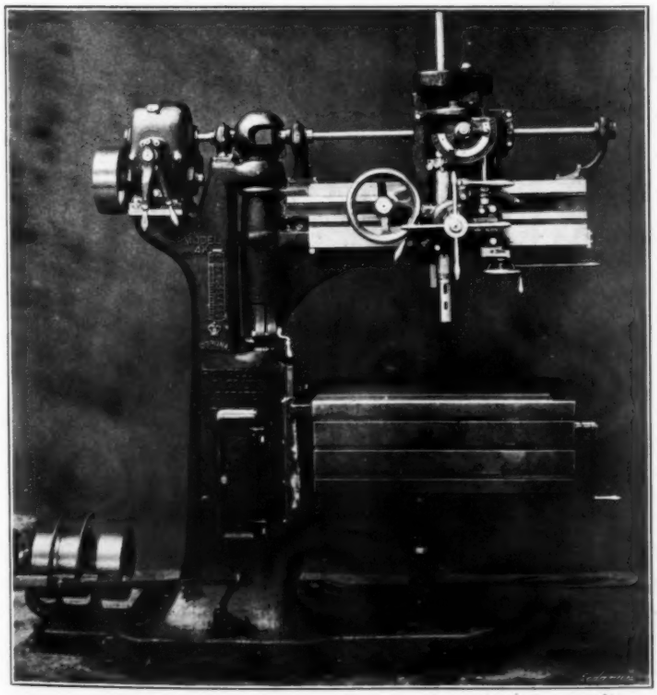
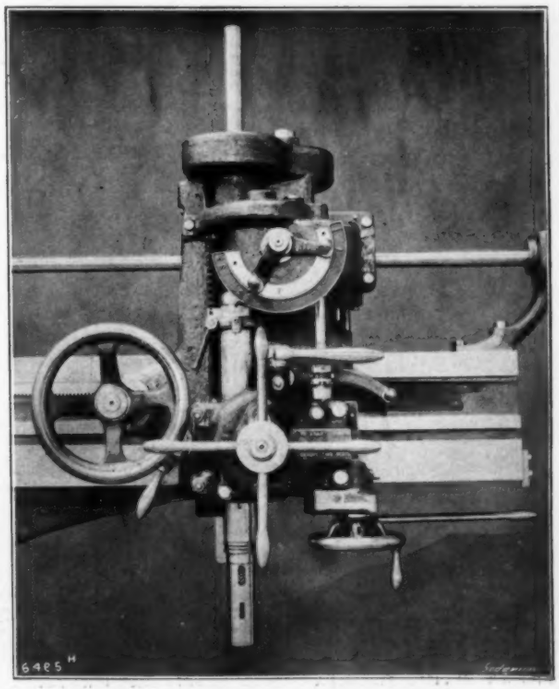


FIG. 92. 27-IN. UPRIGHT DRILL; MESSRS. FREDERICK POLLARD & CO., LTD.



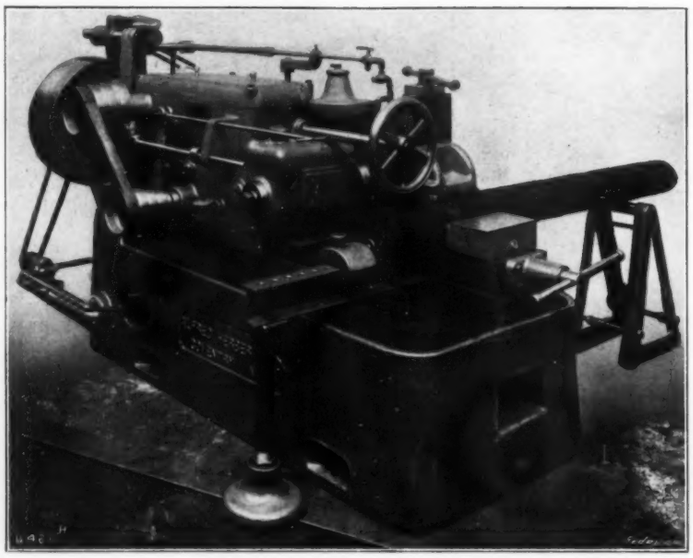


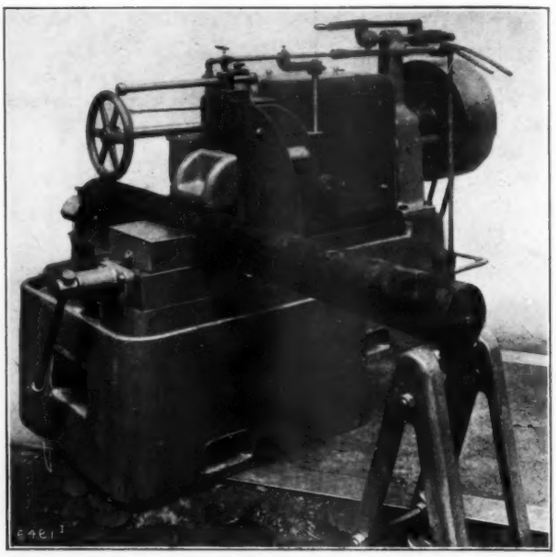
FIGS. 93 AND 94. 36-IN. ALL GEARED RADIAL DRILL; MESSRS. FREDERICK POLLARD & CO., LTD.

(*To face page* 340.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 333.)





FIGS. 95 AND 96. 6-IN. CIRCULAR COLD-SAWING MACHINE; MESSRS. ALFRED HERBERT, LTD.

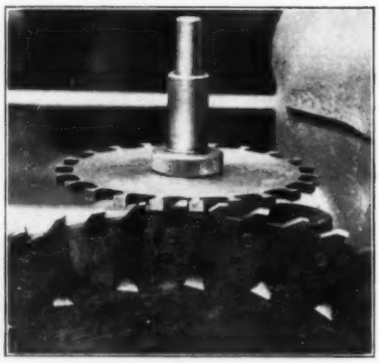


FIG. 97. CHIP REMOVER; HERBERT COLD-SAWING MACHINE.

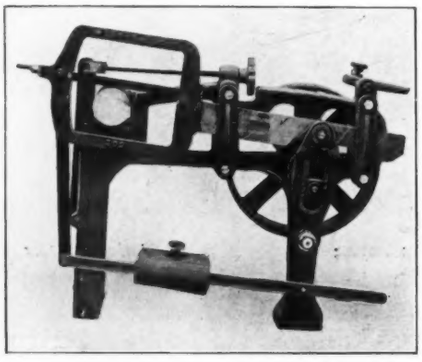


FIG. 98. 3-IN. HACK SAW; MESSRS. CHARLES WICKSTEED AND CO. (1920), LTD.

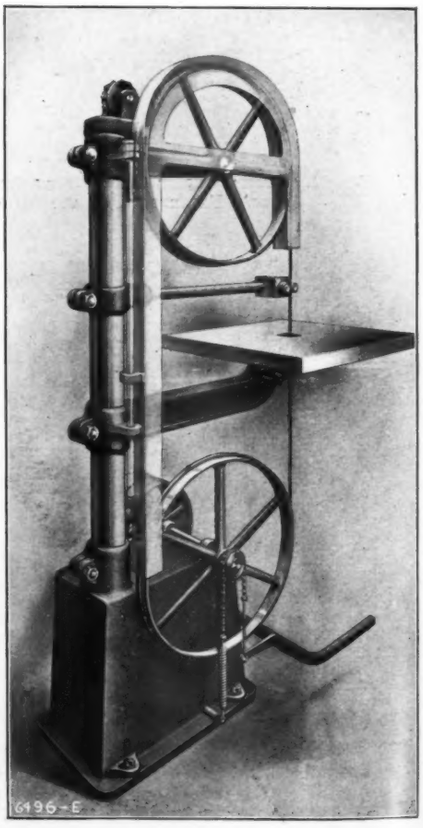


FIG. 100. BAND-SAWING MACHINE; MESSRS. BLACKER, LTD.

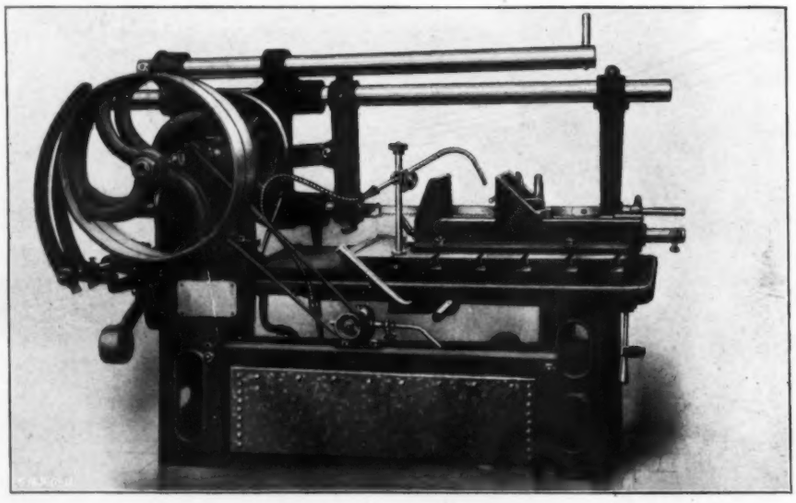


FIG. 99. "VILVALLE" HEAVY DUTY SAWING MACHINE; MESSRS. W. A. WALLER AND CO.

(*To face page* 341.)

TABLE II.

$$\frac{1}{\text{aerial efficiency}} = \frac{1}{\eta}.$$

$\beta = \frac{R_{sc}}{R_m}$	$\gamma = \lambda/\lambda_m$ = 0·5	0·75	1	1·5	2	2·5	3	4	5
0·1	1·33	2·03	3·33	8·5	18	34	58	134	259
0·2	1·44	2·28	3·75	9·4	20	37	62	141	270
0·3	1·57	2·56	4·3	10·6	22	40	67	150	283
0·4	1·75	2·96	5·0	12·2	25	45	73	161	301
0·5	2·0	3·53	6·0	14·5	29	51	82	177	326

TABLE III.

Power in kilowatts for D = 1,000 km.

λ_m	β	γ=0·5	γ=0·75	γ=1	γ=2	γ=3	γ=5
0·5	0·1	8·05	4·1	3·5	5·5	10·1	26·0
	0·5	12·10	7·1	6·3	8·7	14·25	32·75
1·0	0·1	1·4	1·0	1·0	2·3	4·9	14·85
	0·5	2·1	1·7	1·8	3·6	6·95	18·7
2·5	0·1	0·3	0·275	0·335	1·05	2·6	9·1
	0·5	0·45	0·475	0·6	1·65	3·7	11·4
5·0	0·1	0·135	0·145	0·2	0·7	1·9	7·05
	0·5	0·2	0·25	0·35	1·1	2·65	8·9
10·0	0·1	0·075	0·09	0·13	0·535	1·5	5·95
	0·5	0·115	0·16	0·235	0·845	2·125	7·5

TABLE V.

Power in kilowatts for D = 3,000 km.

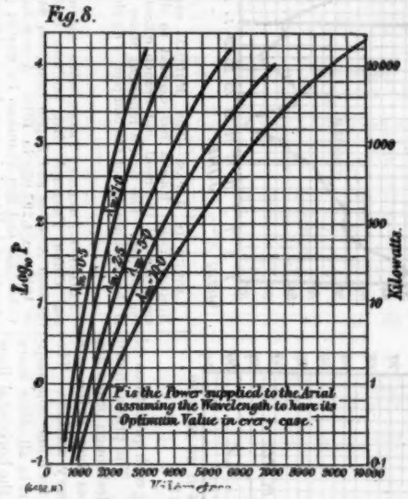
λ_m	β	γ=0·5	γ=0·75	γ=1	γ=2	γ=3	γ=5
0·5	0·1	—	—	155,000	20,200	12,200	10,450
	0·5	—	—	280,000	31,750	17,200	13,150
1·0	0·1	62,000	8,825	3,650	1,430	1,410	1,950
	0·5	93,000	15,300	6,575	2,200	1,990	2,450
2·5	0·1	560·0	195·0	135·0	140·0	210·0	445·0
	0·5	840·0	340·0	240·0	220·0	295·0	560·0
5·0	0·1	54·0	28·5	25·0	42·5	72·5	211·5
	0·5	81·0	50·0	45·0	67·5	102·5	265·5
10·0	0·1	10·0	7·5	8·0	18·5	40·5	125·0
	0·5	15·0	12·5	14·0	29·0	57·5	160·0

TABLE VI.

Power in kilowatts for D = 5,000 km.

λ_m	β	γ=0·5	γ=0·75	γ=1	γ=2	γ=3	γ=5
1·0	0·1	—	—	—	275,000	125,000	78,500
	0·5	—	—	—	435,000	177,000	99,000
2·5	0·1	330,000	43,500	16,600	5,600	5,200	6,800
	0·5	495,000	75,500	30,000	8,800	7,350	8,550
5·0	0·1	6,650	1,770	1,010	700	1,050	1,950
	0·5	10,000	3,085	1,820	1,250	1,485	2,450
10·0	0·1	405	180	145	195	335	805
	0·5	610	315	260	310	475	1,010

Fig. 8.


Log10 P
Kilowatts.
P is the Power supplied to the Aerial assuming the Wavelength to have its Optimum Value in every case.
Wavelength

P is the power supplied to the aerial assuming the wavelength to have its optimum value in every case.

Fig. 9.

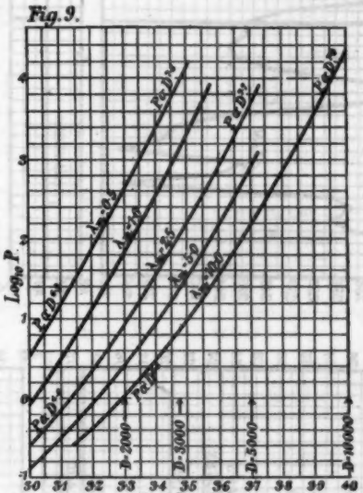


TABLE IV.

Power in kilowatts for D = 2,000 km.

λ_m	β	γ=0·5	γ=0·75	γ=1	γ=2	γ=3	γ=5
0·5	0·1	13,000	2,200	980·0	445·0	475·0	695·0
	0·5	19,500	3,800	1,765·0	700·0	660·0	875·0
1·0	0·1	395·0	125·0	80·0	75·0	110·0	225·0
	0·5	590·0	215·0	145·0	120·0	155·0	285·0
2·5	0·1	17·0	10·0	9·0	16·0	31·0	84·5
	0·5	25·5	17·0	16·0	25·5	44·0	106·5
5·0	0·1	3·6	2·7	2·9	7·35	16·4	51·5
	0·5	5·35	4·2	5·25	11·65	23·15	65·0
10·0	0·1	1·15	1·1	1·35	4·2	10·4	36·25
	0·5	1·75	1·9	2·4	6·65	14·75	45·75

TABLE VII.

Power in kilowatts for D= 10,000 km.

λ_m	β	γ=1	γ=2	γ=3	γ=5
2·5	0·1	—	—	—	1,915,000
	0·5	—	—	—	2,410,000
5·0	0·1	—	365,000	202,500	156,500
	0·5	—	580,000	286,000	210,000
10·0	0·1	66,500	22,350	20,750	27,250
	0·5	120,000	35,300	29,400	34,300

TABLE VIII.

The optimum wavelength in kilometres and the minimum power in kilowatts required to give 0·37 microvolts per centimetre assuming the Austin-Cohen exponential factor.

D	λ_m=0·5		λ_m=1		λ_m=2·5		λ_m=5		λ_m=10	
Kms.	λ	P	λ	P	λ	P	λ	P	λ	P
1,000	0·5	3·5	0·9	0·9	1·75	0·27	2·5	0·134	5·0	0·076
2,000	1·15	430·0	1·5	70·0	2·4	9·0	4·0	2·7	7·5	1·1
3,000	2·5	10,500	2·5	1,400	3·5	117·0	5·0	25·0	8·5	7·3
5,000	—	—	6·0	75,000	7·0	5,100	8·75	770·0	12·5	150·0
10,000	—	—	—	—	—	—	25·0	157,000	30·0	20,000

If the values of β and γ are known the corresponding value of η can be substituted in the formula established above for the power P which must be supplied to the transmitting aerial. It is seen that P depends only on β, γ, D, and λ_m. We have calculated P for five values of D, viz., 1,000, 2,000, 3,000, 5,000 and 10,000 km., for two values of β, viz., 0·1 and 0·5, for six values of λ, viz., 0·5, 0·75, 1·0, 2·0, 3·0 and 5·0, and for five values of γ_m, viz., 0·5, 1·0, 2·5, 5·0 and 10·0 km. The actual wavelength in any case is equal to $\gamma\lambda_m$.

The values of the power P in kilowatts are given in the Tables III to VII, and in Figs. 3 to 7. The curves have only been plotted for one value of β, viz. $\beta = 0{\cdot}1$.

It must be remembered that these figures are based upon the Austin-Cohen exponential factor, which is of uncertain application for distances greater than about 5,000 km., and for wavelengths exceeding about 10 km. Of less importance are the assumptions as to the constancy of the conductor resistance, and of the power-factor of the dielectric losses of the aerial.

The tables and curves bring out clearly the enormous saving of power which can be obtained by using aerials with high values of λ_m, that is with such small dielectric losses that the minimum total effective resistance is reached at long wavelengths.

Many of the very high values of P given in the tables are quite impracticable, since they could only be attained at impossibly high aerial voltages. They are given, however, to show the relation of the power actually employed to that which would be necessary to give signals of the assumed strength.

For a given aerial and therefore a given value of λ_m, there is always a wavelength $\lambda = \gamma\lambda_m$ at which the power necessary for a given distance is a minimum. At longer wavelengths the inefficiency of the aerial more than counteracts the improved transmission. Table VIII shows the power P in kilowatts for various distances with aerials of different values of λ_m on the assumption that the wavelength is always chosen to require the minimum value of P, and that $\beta = 0{\cdot}1$. The wavelength is also given in each case.

These results are shown in Fig. 8 where the ordinates represent the logarithm of the power P in kilowatts. The actual values of P are indicated in the right-hand side of the figure. In Fig. 9, $\log_{10}$ P is plotted against $\log_{10}$ D. If the power varied with the distance according to the law $P = m D^n$, we should have $\log P = \log m + n \log D$ and the curves of Fig. 9 would be straight lines. The slope of the curves gives the value of the index n, which is not a constant; its value at several points is indicated in Fig. 9.

The limiting factor in the amount of power which can be supplied to a given aerial is the voltage of the aerial at which, even if the insulators do not fail, the losses due to discharge from the wires increase very rapidly. This limiting voltage will depend on the size of wires employed and on the design of the insulators, &c., but for large well constructed aerials will probably be in the neighbourhood of 100,000 volts.

Since $I = 2\pi f V C$ where C is in farads, I in amperes and V in volts

we have

$$V = 0{\cdot}53 \frac{I\lambda}{C} = \frac{I\lambda}{2C'} \text{ kilovolts approximately.}$$

where C' is in milli-microfarads and λ in kilometres.

For example, if $C' = 12$ milli-microfarads

$\lambda = 11$ km.

and $I = 200$ amperes

$$V = 0{\cdot}53 \frac{200 \times 11}{12} = 97 \text{ kilovolts.}$$

Since the power P in kilowatts is equal to $I^2 R/1{,}000$, where R is the total effective resistance at the working wavelength, $I = \sqrt{\frac{1{,}000\,P}{R}}$ and

$$V = 17 \frac{\lambda}{C'} \sqrt{\frac{P}{R}} \text{ kilovolts.}$$

It is therefore a simple matter to see whether any power P can be supplied at a given wavelength to an aerial of known capacity and resistance without exceeding the permissible voltage. Conversely, from the formula

$$P = \frac{C'^2 V^2 R}{280\lambda^2} \text{ kilowatts}$$

one can calculate the power corresponding to a given value of V. For example, if $C' = 12$ milli-microfarads, $V = 100$ kilovolts, $R = 3{\cdot}75$ ohms and $\lambda = 11$ km. (these values apply approximately to the San Paolo, Rome, aerial) we have as the maximum power

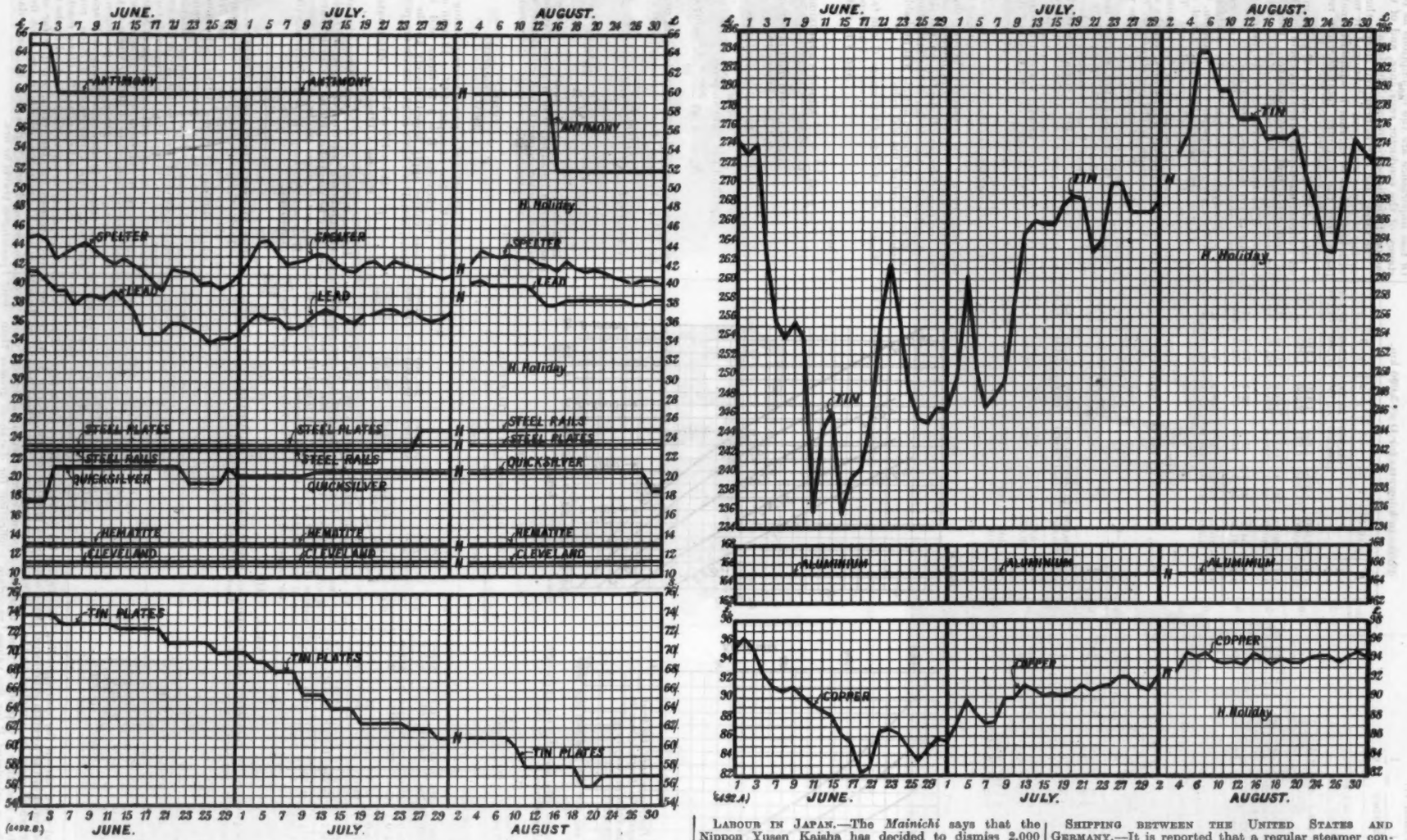
$$P = \frac{144 \times 10^4 \times 3.75}{280 \times 121} = 160 \text{ kilowatts.}$$

Hence in some cases it may be inadvisable to work at the optimum wavelength given in Table VIII and one may be compelled to use a shorter wavelength and consequently more power than that given in Table VIII in order to keep the aerial voltage within the prescribed limits.

THE DANISH AIR TRAFFIC COMPANY.—The Danish Air Traffic Company, after protracted preparatory work, was able to start regular traffic on the 7th inst., the Danish Ministry of Public Works having sanctioned the conditions of the programme. The commencement was made with a Friederichshafen machine, starting from the seaplane station of the Royal Dockyard, Copenhagen, and the first route to be worked is Copenhagen—Berlin, with an intermediate stoppage at Malmo, Sweden, and a change at Warnemünde to the aeroplane for Berlin. The fare per passenger is 400 kr. from Copenhagen to Warnemünde. Until the route Copenhagen—London is opened there will also be a change at Warnemünde for Hamburg. The Copenhagen—London route will be opened shortly and four De Havilland machines, which are expected to arrive from England in the near future, are intended for this traffic, going as far as Hamburg. On the Copenhagen—Berlin route some five seaplanes are engaged and flights will be made daily whether passengers travel or not.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin plates, where they represent 1*s.* each.

LABOUR IN JAPAN.—The *Mainichi* says that the Nippon Yusen Kaisha has decided to dismiss 2,000 employees at the head and branch offices throughout the country. The figures represent about 20 per cent. of the total number of the company's employees.

JAPANESE-AMERICAN TRADE.—We read in *The London and China Telegraph* that business cable messages between America and Japan rose from 945,000 words in 1915, to 4,297,000 in 1918. A new cable between Yokohama and San Francisco by way of the Marshall Islands and Hawai is now being planned, and it is anticipated that it will cost 42,000,000 yen.

SHIPPING BETWEEN THE UNITED STATES AND GERMANY.—It is reported that a regular steamer connection between the United States and Germany is getting into full swing, under the auspices of the newly formed United States Mail Steamship Company. The Susquehannah, formerly the Rhein, has arrived at Bremerhaven, whence she is to proceed to Dantzig, again calling at Bremerhaven on the return voyage. The George Washington will be placed on this trade later on. The company is to have a fleet of smaller boats in the Baltic trade, for distribution of goods from the larger American steamers. The Danzig route is also to be worked and several boats are being got ready for this route, which proves America's aims in European trade.

A HIGH SPEED INTERNAL COMBUSTION ENGINE FOR RESEARCH.*

By H. R. RICARDO.

(*Concluded from page* 330).

Efficiency at Reduced Loads with Varying Compression.—Tests were run at compression ratios of 4 : 1 and 6 : 1, using Shell Borneo petrol with the throttle in various positions in order to determine the effect of compression ratio upon the efficiency at reduced loads. The procedure adopted was as follows :—After starting up, the engine was run on full load until everything had settled down when readings of power and fuel consumption were taken and checked against previous tests, the throttle was then closed until the torque was reduced to any desired extent. The speed in all cases being maintained constant at 1,500 r.p.m. With the throttle clamped in any selected position, a large number of fuel consumption readings were taken; weakening the mixture step by step, until the point of maximum economy was reached and passed: when the full available range of mixture strength had been explored in this manner, the supply of fuel and circulating water were cut off and the engine motored at the same speed, without disturbing the position of the throttle. As soon as the mechanical losses had been determined under the conditions of each test, another series was started either with a different throttle opening or a different compression ratio and the same procedure repeated.

In this manner a large number of curves relating the mean effective pressure and throttle opening were obtained, one such series being shown in Fig. 10, in which the crosses denote the actual readings taken with a compression ratio of 6 : 1 and the circles with a ratio of 4 : 1.

It will be observed that, at very small throttle openings, the results are less uniform and also that the available range of mixture strength narrows rapidly as the throttle opening is reduced. Taking the most economical mixture in each case, a curve may be drawn showing the brake and indicated thermal efficiency in terms of percentage of full load.

The results are given in tabulated form below. (See also Fig. 11.)

Fig. 10. CURVES SHOWING RELATION BETWEEN FUEL CONSUMPTION AND INDICATED MEAN PRESSURE

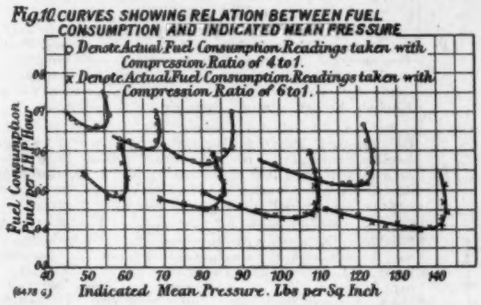

o Denote Actual Fuel Consumption Readings taken with Compression Ratio of 4 to 1.
x Denote Actual Fuel Consumption Readings taken with Compression Ratio of 6 to 1.
Fuel Consumption Pints per I.H.P. Hour
Indicated Mean Pressure. Lbs per Sq. Inch

Fig. 11. CURVES SHOWING BRAKE & THERMAL EFFICIENCY IN TERMS OF PER CENT FULL LOAD.

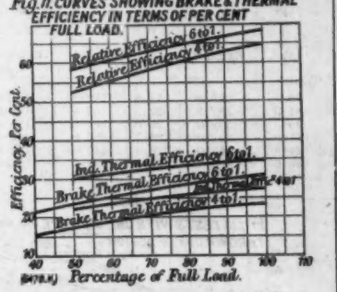

Relative Efficiency 6 to 1.
Relative Efficiency 4 to 1.
Ind. Thermal Efficiency 6 to 1.
Brake Thermal Efficiency 6 to 1.
Brake Thermal Efficiency 4 to 1.
Efficiency Per Cent.
Percentage of Full Load.

TABLE IV.

Per Cent. of Full Load.	Indicated Thermal Efficiency.	Brake Thermal Efficiency.	Relative Efficiency.
	Compression ratio 6 : 1.		
Per Cent.	Per Cent.	Per Cent.	Per Cent.
100	34·9	30·7	68·2
80	33·0	27·5	64·5
60	31·0	25·6	60·6
50	30·0	23·9	58·6
40	—	21·5	—
	Compression ratio 4 : 1.		
100	27·5	23·4	64·6
80	25·8	21·7	60·6
60	23·5	19·0	55·3
50	22·3	17·4	52·4
40	—	15·2	—

From the above results many interesting points arise. It will be observed that reducing the brake power to 40 per cent. by throttling has the effect of reducing the brake thermal efficiency to just 70 per cent. of the full load figure when the compression is 6 : 1 and to 65 per cent. when the compression is 4 : 1. On full load the gain in efficiency from the higher compression ratio is 31 per cent., while on 40 per cent. full load the gain has risen to nearly 42 per cent., a very important consideration in view of the fact that the majority of motor vehicle engines operate on the average at about 40 per cent. of their normal full load torque.

The rapid narrowing of the range of mixture strength as the throttle opening is reduced is also interesting.

Experiments with different fuels proved, as might be expected that each fuel, depending upon its composition, had a certain limiting and very clearly defined compression, after which detonation commenced; at first very slightly, but once it had become apparent, the least further increase in compression resulted in severe detonation followed by loss of power and eventually by pre-ignition. In the case of certain fuels tested no detonation occurred; violent pre-ignition denoted by a dull thud in the cylinder and an immediate and excessive drop in speed being the first indication that the compression had been carried too far. In the case of all ordinary fuels belonging to the general group known as petrol, pre-ignition and loss of power never occurred without passing first through a phase of detonation. By very careful adjustment of the compression ratio between narrow limits, mild detonation could be allowed to persist for unlimited periods without any ill effect, and in many cases a very small, but none the less, distinct improvement in thermal efficiency could be detected when such detonation was taking place.

The phenomena of detonation appear to be substantially as follows :—When a mixture of hydrocarbon vapour and air is compressed to a high pressure and to a temperature approaching that of its self-ignition temperature, and ignition is started from any point, the flame at first spreads from this point, by the normal process of combustion, and compresses before it the unburnt portion of the charge. When the rise in temperature of the unburnt portion due to compression by the burning gases exceeds the rate of heat dissipation by a certain margin, spontaneous ignition takes place and an explosion wave is set up which strikes the wall of the combustion chamber with a hammer-like blow, thus causing the familiar metallic ring known as pinking or detonation. It also has the effect of compressing and still further raising the temperature of the portion first ignited and with it the temperature of the igniter points. If detonation be allowed to persist, it will, unless it be very slight, increase in severity and ultimately raise the temperature of the sparking plug points or some other partially insulated object in the combustion chamber, to such a degree as to cause pre-ignition, quite a distinct phenomenon.

There appears to be little doubt but that detonation depends first upon the normal rate of burning of the fuel and this in turn is largely dependent both upon the pressure and temperature prior to ignition. Further, it seems clear that pre-ignition which is the ultimate determining factor in the compression which may be used, is almost invariably brought about by detonation in the first instance. If detonation be prevented by retarding the normal rate of flame propagation by such means as, for example, the introduction of a very small quantity of CO_2, along with the mixture, a very much higher compression can be used without any risk of pre-ignition. The following observations in connection with detonation may be of interest :—

(1) It appears without doubt to depend both upon pressure and temperature. When compression is carried out in two stages with inter-cooling between stages, detonation occurs at nearly the same compression pressure as when it is obtained by compression in a single cylinder. It has been observed, also, that with any compression ratio, provided the fuel is completely vaporised, the inlet temperature of the working fluid can be raised quite considerably without greatly affecting the tendency to detonate, while, on the other hand, an increase in the compression ratio corresponding to anything approaching a similar increase of compression temperature will be accompanied at once by violent detonation.

(2) It might be expected that increased turbulence, by distributing the normal spread of flame, and by preventing the isolation and compression of unburnt portions of charge would considerably reduce the risk of detonation; while experiments on many other engines all point to a reduction in the tendency to detonate with increase of turbulence, tests on this particular engine with either one or two inlet valves in operation showed no perceptible difference in this respect, a slightly higher compression ratio could always be used when one inlet valve only was in operation, but it is certain that when allowance is made for wire-drawing, with only one valve, the compression pressure was no higher than with two valves in operation. On the other hand it is possible that, owing to the perfectly symmetrical and generally very favourable form of the combustion chamber, the turbulence was at a maximum even with two valves in operation.

Effect of Ignition.—In this engine four sparking plugs are fitted at equidistant points round the circumference of the cylinder, any or all of which can be operated simultaneously and in perfect synchronism. It was found that detonation was at a minimum when two plugs at opposite sides were operated simultaneously, and at a maximum when one plug only on the inlet valve side was used. This is as might be expected, for the tendency to detonate clearly depends upon (*a*) the distance the flame travels from the ignition point, this is practically halved when two plugs on opposite sides of the combustion chamber are used; (*b*) the temperature of the surfaces against which the unburnt portion is compressed. When fired from the inlet side the unburnt gas is compressed against the hot exhaust valve heads. The difference between firing from the inlet and exhaust valve side was very marked, a fuel which detonated with a 5 : 1 compression ratio when fired from the inlet side would stand as high as 5·15 : 1 when fired from the exhaust side.

The actual timing of the ignition had, of course, a very decided effect. In all cases the limiting compression ratio was defined as that at which the time of ignition could be advanced without detonation until a definite drop in torque occurred. By retarding the ignition, very considerably higher compressions could be used because, owing to the outward movement of the piston the working fluid is expanding, at all events, during the latter period of the ignition process. It was found that by increasing the compression beyond the true limit and retarding the ignition, a very slight increase in torque could be obtained with any given fuel but, of course, at the expense of efficiency. The extreme importance of ascertaining that the whole range of ignition is being used, when running experiments with varying compressions, cannot be too strongly emphasised. Theories that benzol mixtures, alcohol, etc., give appreciably more power than pure petrol owe their origin to the fact that the tests have been carried out on engines in which the compression was already too high to allow of them being operated with full ignition advance on petrol, and the gain in power and efficiency observed when benzol or benzol mixtures were tested was due solely to the fact that only with such fuels could the correct ignition timing be used.

One feature of considerable interest has been repeatedly observed. When using one sparking plug only, if detonation be allowed to persist for some length of time, and the plugs removed and examined immediately the engine stopped, it was invariably found that the electrodes of the three which had been inoperative were always cool and coated with a thin layer of partially carbonised oil, while those of the plug in operation showed every evidence of having attained a very high temperature, for they would be found to be quite free from carbon and of an angry red colour, while in some instances the extreme tips would be partially fused. This effect could be produced with any of the four plugs; it affords a very interesting illustration of Professor Hopkinson's theory that when detonation occurs, a zone of very high temperature is always formed around the spot from which ignition first started due to further compression of the already burning gases, and it is no doubt this effect which ultimately causes pre-ignition and so sets a limit to the ratio of compression which may be used. The general conclusions arrived at so far may be summed up as follows :—

(1) The limiting compression which can be used with all commercial petrols and many other similar fuels is controlled by the tendency to detonate which in turn is governed by the normal rate of burning. If means be employed for slowing down the normal rate of burning such, for example, as the addition of a small quantity of CO_2 or by suitable blending of the fuels, much higher compression ratios can at once be employed. Pre-ignition which, in fact, controls and limits the ratio of compression is in nearly every case brought about by some local rise of temperature due to persistent detonation. Pre-ignition without preliminary detonation never occurs with any fuels of the petrol group. It does occur with certain fuels which have been investigated, but only at very much higher compressions than can possibly be reached with petrols.

(2) For any given fuel the tendency to detonate depends, apart from the compression ratio, upon :—

(*a*) The form of the combustion chamber.

(*b*) The number and position of the igniters.

(*c*) The inlet temperature of the working fluid and to some slight extent upon the cylinder temperature.

(*d*) The degree of turbulence (though, as already stated, the experiments on this particular engine were inconclusive upon this point).

(*e*) The strength of the mixture; unfortunately, however, detonation is most apparent over that range of mixture strength which lies between the points of maximum economy and maximum power, so that it cannot be dodged without paying heavily.

In all some hundreds of tests have been made on numerous different fuels in order to ascertain the relationship between mixture strength, power and economy. The procedure adopted is as follows :—After the engine has thoroughly warmed up and all adjustments as to temperature, &c., have been made, the needle valve in the carburettor is opened until maximum torque is obtained and slightly passed, when a reading of fuel consumption is taken. The needle valve in the carburettor is then closed slightly and another reading taken, this procedure being repeated until the mixture has been so weakened that the engine will no longer run steadily. The results obtained are then worked out and plotted in terms of pints per indicated horse-power hour against indicated mean pressure. On the average, from 10 to 15 readings are taken between the limits of maximum torque and the weakest mixture upon which the engine will run steadily, the results obtained are as shown in Fig. 12, which are two typical curves taken with a light petrol and with benzol at the same compression. It will be noted that the point of maximum economy and maximum torque are very nearly co-incident, more particularly on petrol. This is characteristic of all the volatile liquid fuels yet tested but, of course, is very distinct from coal gas. In fact the divergence between light petrol and benzol is the greatest so far observed. The general form and characteristics of this curve may be taken as applying to any fuel and at any compression ratio. There was no evidence either that the range of burning increased or that a weaker mixture could be burnt with higher compressions. Several such directly comparative tests were made with compression

* Paper read before Section G of the British Association at Cardiff, August 25, 1920.

ratios of 4 : 1 and 7 : 1, and many more at 4 : 1 and 6 : 1, which latter came within the range of a greater number of fuels.

Ignition and Power.—Some tests were made in order to ascertain whether any gain either in power or economy could be effected by using more than one ignition plug. All fuel tests were run with two plugs on opposite sides of the combustion chamber. When either plug was cut out and no change made in the ignition timing, the mean pressure at 1,500 r.p.m. always fell about 3 lb. to 4 lb. per square inch, and the efficiency in a similar proportion. It was found, however, that provided the compression ratio was well within the range of the fuel the torque and efficiency could be completely restored by advancing the ignition point. The effect of this is, however, that the tendency to detonate is increased, with the result that a somewhat lower compression ratio must be used and the power and efficiency reduced thereby. It was found, for example, that a fuel which could stand a compression ratio of 5·4 : 1 when two plugs were in operation with 36 deg. ignition advance, a setting which gave maximum torque at 1,500 r.p.m. detonated heavily when run with one plug at the same power with 42 deg. advance. To avoid such detonation it was necessary to reduce compression to 5·25 : 1.

Although with a definite compression ratio, so long as it is well within the limits imposed by the fuel, no gain in power could be observed by using more than one ignition; yet even under these conditions the smaller range of ignition required to maintain maximum torque is a real practical advantage; also it must be remembered that in the majority of petrol engines, the compression is already too high, and detonation generally becomes apparent when the most efficient ignition and mixture adjustments are used, consequently anything which will tend to reduce detonation becomes of practical importance.

4. Another series of tests were carried out with one or more valves out of operation in order to determine the relation between gas velocity through the valves and mean pressure.

In the first series one of the two inlet valves were put out of operation and a torque-speed curve taken at speeds up to 1,900 r.p.m. This curve, together with that obtained with both valves in operation, is shown in Table No. V, columns Nos. 1 and 4, on which are given also the corresponding gas velocities. It will be observed that the mean effective pressure when operating with one inlet valve only is, at all times, lower than when both are in operation, and that the torque falls away very rapidly at speeds above 1,200 r.p.m., corresponding to a piston speed of 1,600 ft. per minute and an inlet gas velocity of 175 ft. per second.

In the second series one of the three exhaust valves was thrown out of operation, and the torque obtained under these conditions is given in Table No. V, column 2. It will be observed that the torque curves are almost identical up to a speed of 1,700 r.p.m., corresponding to a piston speed of 2,270 ft. per minute and a gas velocity through the exhaust ports of about 260 ft. per second.

Lastly, a test was made with one exhaust valve only in operation, the results of which are shown in Table No. V, column 3. The results of all these tests are given in Table V. and Fig. 13. These tests are interesting from a designer's point of view, but call for no particular comment.

All the figures are given in terms of indicated mean pressure for the reasons stated earlier; it should be mentioned, however, that immediately after each of the above torque curves were taken the mechanical losses were measured afresh by motoring, and the increased pumping losses so found allowed for in estimating the indicated mean pressure. It must be admitted that in the case of exhaust back pressure, motoring tests are liable to over-estimate the true pumping losses. The discrepancy, however, is a comparatively small one.

5. Effect of Inlet Temperature.—A number of experiments were carried out in order to ascertain the relation between the temperature of the gases entering the cylinder and the mean pressure. It was found that the inlet temperature could be controlled with extreme nicety by means of the electrical heating provided in the air-intake to the carburettor, and in all the tests referred to previously a constant inlet temperature was maintained. When a light and highly volatile fuel was being used it was found that the mean effective pressure dropped 0·47 lb. per square inch per degree Centigrade so long as the inlet temperature was over 10 deg. C. and at a compression ratio of 5 : 1. This is in fair agreement with the variation in density of the charge. When, however, a less volatile fuel was used it was found that the drop in mean pressure was very much less, and in some instances was hardly perceptible over a considerable range of temperature. The obvious explanation is that so long as the whole of the fuel is evaporated outside the cylinder the mean effective pressure is proportional to the absolute temperature of the charge, but when a less volatile fuel is used, a considerable proportion enters the cylinder in a finely divided though still liquid state, and evaporation takes place within the cylinder during the suction stroke, as the finely divided liquid particles come into contact with the hot walls and the residual exhaust gas. Owing to the heat absorbed by the evaporation of the fuel it is to be presumed that under these conditions the true suction temperature, as distinct from what has hitherto been termed the inlet temperature, remains practically constant.

Lastly, a few tests were made in order to ascertain the influence of the inlet temperature on the limiting compression ratio. The fuel used for this purpose was pure hexane, a highly volatile fuel, and the following results were observed :—

TABLE VI.

Heat Supplied to Electrical Heater	Fuel Consumption (pint per hour).	Inlet Temperature.	Compression Ratio at which Slight Detonation Occurred.
None	16	— 4 deg. C.	5·5 : 1
280 watts	16	— 2 deg. C.	5·3 : 1
1,570 ,,	15·5	9 deg. C.	5·2 : 1
2,000 ,,	14·5	24 deg. C.	5·05 : 1

In the first two tests the bulk of the fuel no doubt entered the cylinder in a liquid state, while in the last two tests it is probable that nearly all was evaporated. The range of suction temperature will therefore be very much greater than that of the inlet temperature. On the occasion when these tests were made the temperature of the outside air was approximately 15 deg. C.

The experiments dealt with above, together with many other tests on some 40 different fuels, have occupied about eight months, during which time the engine has been in operation on the average about 15 hours per week, a total to date of between 500 and 600 hours. At least 90 per cent. of the running has been with wide open throttle at a steady piston speed of 2,000 ft. per minute and with an average mean pressure of about 135 lb. per square inch. Since the first calibration tests the engine has only been opened up on two occasions when, beyond grinding in the valves and thoroughly cleaning out, no repairs or adjustments of any kind were required, nor has any measurable wear developed in any part.

The connecting rod big end bearing, the most severely stressed bearing in the engine, has not only shown no measurable wear at all, but even after running for four or five hours on full load its temperature is found not to exceed 40 deg. C.

Owing to the reduction of friction throughout the temperature of the base chamber and lubricating oil does not exceed 35 deg. C. after four hours.

A careful comparison between a set of torque and efficiency curves taken in December of last year, and a similar set taken with the same fuel in June of this year show that the performance of the engine has not varied by more than 0·5 per cent. during a period of six months.

The experiments enumerated above represent but a comparatively small proportion of those carried out to date, but time does not permit of dealing with more or of enlarging upon the deductions which may be drawn from them.

In conclusion, the writer would like to express his thanks to Sir Robert Waley Cohen and the Asiatic Petroleum Company for their courtesy in allowing him to publish the results of experiments carried out on their engine : also to Mr. Tizard, Mr. Thornycroft and Mr. Pye for their great assistance both in carrying out the tests and analysing the results obtained from them.

TABLE V.—TESTS WITH ONE OR MORE VALVES THROWN OUT OF OPERATION.

I.H.P. (Compression ratio 6 : 1 in all cases.)

Number of Valves in Operation and Mean Gas Velocity.

	Column No. 1.			Column No. 2.			Column No. 3.			Column No. 4.		
	No. of Valves 2 inl. 3 exh.			No. of valves 2 inl. 2. exh.			No. of valves 2 inl. 1 exh.			No. of valves 1 inl. 3 exh.		
	Gas velocity, Ft. per Sec.		I.H.P.	Gas velocity, Ft. per Sec.		I.H.P.	Gas velocity, Ft. per Sec.		I.H.P.	Gas velocity, Ft. per Sec.		I.H.P.
R.P.M.	Inlet	Exhaust		Inlet	Exhaust		Inlet.	Exhaust.		Inlet.	Exhaust.	
900	66·1	86·6	19·9	66·1	137·2	20·0	66·1	235·0	18·8	132·2	86·6	19·1
1,100	81·0	106·0	24·5	81·0	168·0	24·55	81·0	287·5	22·9	162·0	106·0	23·0
1,300	95·5	125·0	29·4	95·5	198·0	29·4	95·5	339·0	26·0	191·0	125·0	27·0
1,500	111·0	144·5	34·5	111·0	228·5	34·4	111·0	391·0	26·7	222·0	144·5	30·7
1,700	124·8	163·0	39·8	124·8	259·0	39·3	124·8	443·0	26·4	249·6	163·0	33·8
1,900	139·6	183·0	45·1	139·6	290·0	44·3	139·6	496·0	25·2	279·2	183·0	36·0

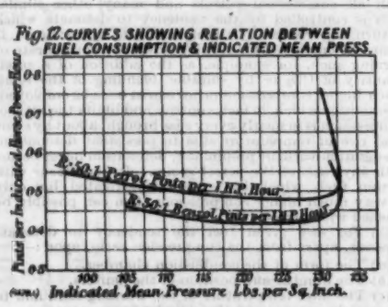
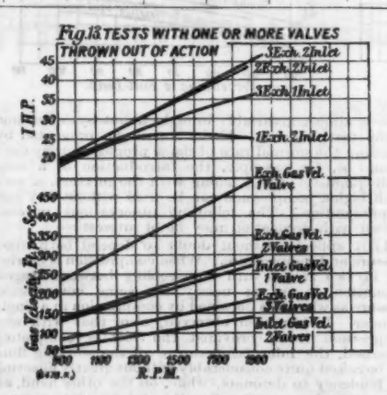


Fig. 12. CURVES SHOWING RELATION BETWEEN FUEL CONSUMPTION & INDICATED MEAN PRESS.
Pints per Indicated Horse Power Hour
0·8
0·7
0·6
0·5
0·4
0·3
R=5·0 : 1 Petrol. Pints per I.H.P. Hour
R=5·0 : 1 Kerosol. Pints per I.H.P. Hour
100 105 110 115 120 125 130 135
(Scale) Indicated Mean Pressure Lbs. per Sq. Inch.



CATALOGUES.

Types of Machinery.—A finely printed and illustrated catalogue of 44 pages has been issued by Messrs. Peter Brotherhood, Limited, Peterborough, containing illustrations of the many types of marine and other machinery made by them with brief descriptive paragraphs in English, French, Italian, Spanish and Russian.

Rubber and Asbestos.—Messrs. George MacLellan and Co., Limited, Maryhill, Glasgow, have issued a 30-page booklet containing a revised reprint of some illustrated articles written a few years ago by Mr. J. G. Ketchen, describing their works and various manufactures in a popular style which makes very interesting reading.

Line Shaft Bearings.—The application of Hyatt flexible roller bearings, to line shafting, countershafting, &c., is dealt with in a special catalogue issued by Messrs. Hyatt, Limited, 24, Devonshire-street, Theobalds-road, London, W.C. 1, who supply complete plummer blocks, hangers, wall boxes, and a large range of housings in standard sizes.

Pyrometer Outfit.—A pyrometer set for use with their Wild-Barfield furnaces has been prepared by Automatic and Electric Furnaces, Limited, 281, Gray's Inn-road, London, W.C. 1, who send a catalogue illustrating both protected and unprotected thermo-couples A four-page circular explaining the use and possible defects of pyrometers is also enclosed.

Marine Oil Engine.—A catalogue describing the operation of a British Kromhout oil engine of 260 brake-horse-power comes from Messrs. Perman and Co., Limited, 82, Fenchurch-street, London, E.C. 3. This is a two-stroke engine with four cylinders, 15½ in. in diameter and 17¾ in. stroke. The starting and reversing is effected by compressed air and an auxiliary engine is carried for driving the compressor. A blow-lamp is used for starting. The normal speed is 240 r.p.m., but the engine will run at any speed from 100 r.p.m. up to the normal for any length of time.

Milling Cutters.—A special booklet catalogue of milling cutters and reamers issued by the B.S.A. Tools, Limited, Birmingham, exceeds 130 pages. All the standard forms are included with a great range of sizes, of which precise particulars are tabulated in each case. All are made of high-speed steel. The prices range from a few shillings up to over 40*l.* for a single cutter. The catalogue contains much useful information about the practical use of these tools and is altogether a striking proof of the importance attained by milling methods in a comparatively brief time. The selling agents are Messrs. Burton, Griffiths and Co., Limited, Ludgate square, London, E.C. 4. This catalogue is priced at 2*s.* 6*d.* net per copy.

Horizontal Steam Engines.—A range of horizontal steam engines for mill and general machinery driving is described in a catalogue received from Messrs. Marshall, Sons and Co., Limited, Gainsborough. The powers listed range from 21 effective horse-power to about 150 effective horse-power. The engines are made in four variations or "classes," which would seem complicated if defined in series, but the meaning is simply that the steam engine is capable of adaptation to the local conditions of space, water supply for condensing, available boiler pressure, constancy or otherwise of load, &c. Where there are limiting local conditions it is best for the factory owner to consult the engine maker in order to get the most suitable and the most economical engine. A very considerable difference in the running cost and even in the capital cost may be effected by proper selection : for instance, there are many cases in which the simple engine is the best possible prime mover for use, and others in which the adoption of compound condensing sets prove a substantial economy.